NASA SP-222(05)

THE NASTRAN® USER'S MANUAL

(Level 17.5)

FOR EARLY DOMESTIC DISSEMINATION

Because of its significant early commercial potential, this information, which has been developed under a U. S. Government program, is being disseminated within the United States in advance of general publication. This information may be duplicated and used by the recipient with the express limitation that it not be published. Release of this information to other domestic parties by the recipient shall be made subject to these limitations. Foreign release may be made only with prior NASA approval and appropriate export licenses. This legend shall be marked on any reproduction of this information in whole or in part.

Date of general release December 29, 1980.

December 1978

Scientific and Technical Information Office
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C.

For sale from Computer Software Management and Information Center (COSMIC)
Barrows Hall, University of Georgia, Athens, Georgia 30601 – Price $15.50

"Page missing from available version"

REST OF
Document is in original format
e
is not missing pages.

TABLE OF CONTENTS (Continued)

Section		Page No.
1.10.1.4	Dynamic Analysis	1.10-10
1.10.1.5	DMAP Loops for Phase 2	1.10-11
1.10.1.6	Identical Substructures	1.10-12
1.10.2	Automated Multi-Stage Substructures	1.10-36
1.10.2.1	Basic Concepts	1.10-36
1.10.2.2	Substructure Operations and Control Functions	1.10-38
1.10.2.3	Input Data Checking and Interpretation of Output	1.10-41
1.10.2.4	Substructure Operating File (SØF)	1.10-48
1.10.2.5	The Case Control Deck for Automated Substructuring Analyses	1.10-50
1.10.2.6	User Aids for Automated Substructuring Analysis	1.10-51
1.10.2.7	Examples of Automated Substructuring Analysis	1.10-52
1.11	AEROELASTIC MODELING	1.11-1
1.11.1	Introduction	1.11-1
1.11.2	Aerodynamic Modeling	1.11-2
1.11.2.1	Doublet-Lattice Panels	1.11-2
1.11.2.2	Slender and Interference Bodies	1.11-3
1.11.2.3	Mach Box Theory	1.11-4
1.11.2.4	Strip Theory	1.11-6
1.11.2.5	Piston Theory	1.11-7
1.11.3	The Interconnection Between Structure and Aerodynamic Models	1.11-8
1.11.4	Modal Flutter Analysis	1.11-10
1.12	CYCLIC SYMMETRY	1.12-1
1.13	FULLY STRESSED DESIGN	1.13-1
2.	NASTRAN DATA DECK	
2.1	GENERAL DESCRIPTION OF DATA DECK	2.1-1
2.2	EXECUTIVE CONTROL DECK	2.2-1
2.2.1	Executive Control Card Descriptions	2.2-1
2.2.2	Executive Control Deck Examples	2.2-5
2.3	CASE CONTROL DECK	2.3-1
2.3.1	Data Selection	2.3-1

Section			Page No.
	2.3.2	Output Selection	2.3-2
	2.3.3	Subcase Definition	2.3-3a
	2.3.4	Case Control Card Descriptions	2.3-6
2.4	BULK DATA DECK		2.4-1
	2.4.1	Format of Bulk Data Cards	2.4-1
	2.4.2	Bulk Data Card Descriptions	2.4-4
2.5	USER'S MASTER FILE		2.5-1
	2.5.1	Use of User's Master File	2.5-1
	2.5.2	Using the User's Master File Editor	2.5-2
	2.5.3	Rules for the User's Master File Editor	2.5-3
	2.5.4	Examples of User's Master File Editor Usage	2.5-3
	2.5.5	NASTRAN Demonstration Problems	2.5-10
2.6	USER GENERATED INPUT		2.6-1
	2.6.1	Utility Module INPUT Usage	2.6-1
		2.6.1.1 Laplace Circuit	2.6-2
		2.6.1.2 Rectangular Frame made from BARs or RØDs	2.6-7
		2.6.1.3 Rectangular Plate made from QUAD1s	2.6-10
		2.6.1.4 Rectangular Plate made from TRIA1s	2.6-13
		2.6.1.5 N-segment String	2.6-16
		2.6.1.6 N-cell Bar	2.6-19
		2.6.1.7 Full Matrix with Optional Unit Load	2.6-21
		2.6.1.8 N-spoked Wheel Made from BAR Elements	2.6-23
2.7	SUBSTRUCTURE CONTROL DECK		2.7-1
	2.7.1	Commands and Their Execution	2.7-4
	2.7.2	Interface with NASTRAN DMAP	2.7-5
	2.7.3	Substructure Control Card Descriptions	2.7-6
	2.7.4	SØF Capatibility	2.7-6
3.	RIGID FORMATS		
3.1	GENERAL DESCRIPTION OF RIGID FORMATS		3.1-1
	3.1.1	Input File Processor	3.1-2

Section			Page No.
	3.1.2	Functional Modules and Supporting DMAP Operations	3.1-4
	3.1.3	Restart Procedures	3.1-5
	3.1.4	Rigid Format Output	3.1-6
3.2	STATIC ANALYSIS		3.2-1
	3.2.1	DMAP Sequence for Static Analysis	3.2-1
	3.2.2	Description of DMAP Operations for Static Analysis	3.2-9
	3.2.3	Case Control Deck and Parameters for Static Analysis	3.2-14
	3.2.4	Automatic Alters for Automated Multi-stage Substructuring	3.2-16
3.3	STATIC ANALYSIS WITH INERTIA RELIEF		3.3-1
	3.3.1	DMAP Sequence for Static Analysis with Inertia Relief	3.3-1
	3.3.2	Description of DMAP Operations for Static Analysis with Inertia Relief	3.3-7
	3.3.3	Case Control Deck and Parameters for Static Analysis with Inertia Relief	3.7-12
	3.3.4	Automatic Alters for Automated Multi-stage Substructuring	3.3-13
3.4	NORMAL MODE ANALYSIS		3.4-1
	3.4.1	DMAP Sequence for Normal Mode Analysis	3.4-1
	3.4.2	Description of DMAP Operations for Normal Mode Analysis	3.4-7
	3.4.3	Automatic Output for Normal Mode Analysis	3.4-12
	3.4.4	Case Control Deck and Parameters for Normal Mode Analysis	3.4-13a
	3.4.5	Automatic Alters for Automated Multi-stage Substructuring	3.4-15
	3.4.6	Optional Diagnostic Output for FEER	3.4-15
	3.4.7	The APPEND Feature	3.4-17
3.5	STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS		3.5-1
	3.5.1	DMAP Sequence for Static Analysis with Differential Stiffness	3.5-1
	3.5.2	Description of DMAP Operations for Static Analysis with Differential Stiffness	3.5-10
	3.5.3	Automatic Output for Static Analysis with Differential Stiffness	3.5-18
	3.5.4	Case Control Deck and Parameters for Static Analysis with Differential Stiffness	3.5-19
3.6	BUCKLING ANALYSIS		3.6-1
	3.6.1	DMAP Sequence for Buckling Analysis	3.6-1

Section			Page No.
	3.6.2	Description of DMAP Operations for Buckling Analysis	3.6-9
	3.6.3	Automatic Output for Buckling Analysis	3.6-15
	3.6.4	Case Control Deck and Parameters for Buckling Analysis	3.6-15
	3.6.5	Optional Diagnostic Output for FEER	3.6-16
3.7		PIECEWISE LINEAR ANALYSIS	3.7-1
	3.7.1	DMAP Sequence for Piecewise Linear Analysis	3.7-1
	3.7.2	Description of DMAP Operations for Piecewise Linear Analysis	3.7-9
	3.7.3	Case Control Deck and Parameters for Piecewise Linear Analysis	3.7-15
3.8		DIRECT COMPLEX EIGENVALUE ANALYSIS	3.8-1
	3.8.1	DMAP Sequence for Direct Complex Eigenvalue Analysis	3.8-1
	3.8.2	Description of DMAP Operations for Direct Complex Eigenvalue Analysis	3.8-9
	3.8.3	Automatic Output for Direct Complex Eigenvalue Analysis	3.8-15
	3.8.4	Case Control Deck and Parameters for Direct Complex Eigenvalue Analysis	3.8-17
3.9		DIRECT FREQUENCY AND RANDOM RESPONSE	3.9-1
	3.9.1	DMAP Sequence for Direct Frequency and Random Response	3.9-1
	3.9.2	Description of DMAP Operations for Direct Frequency and Random Response	3.9-11
	3.9.3	Case Control Deck and Parameters for Direct Frequency and Random Response	3.9-18
	3.9.4	Automatic Alters for Automated Multi-stage Substructuring	3.9-20
3.10		DIRECT TRANSIENT RESPONSE	3.10-1
	3.10.1	DMAP Sequence for Direct Transient Response	3.10-2
	3.10.2	Description of DMAP Operations for Direct Transient Response	3.10-10
	3.10.3	Case Control Deck and Parameters for Direct Transient Response	3.10-16
	3.10.4	The CØNTINUE Feature	3.10-18
	3.10.5	Automatic Alters for Automated Multi-stage Substructuring	3.10-19
3.11		MODAL COMPLEX EIGENVALUE ANALYSIS	3.11-1
	3.11.1	DMAP Sequence for Modal Complex Eigenvalue Analysis	3.11-1
	3.11.2	Description of DMAP Operations for Modal Complex Eigenvalue Analysis	3.11-8
	3.11.3	Automatic Output for Modal Complex Eigenvalue Analysis	3.11-13

Section | Page No.

3.11.4 Case Control Deck and Parameters for Modal Complex Eigenvalue Analysis 3.11-13

3.11.5 Optional Diagnostic Output for FEER 3.11-14

3.11.6 The APPEND Feature 3.11-14

3.12 MODAL FREQUENCY AND RANDOM RESPONSE 3.12-1

3.12.1 DMAP Sequence for Modal Frequency and Random Response 3.12-1

3.12.2 Description of DMAP Operations for Modal Frequency and Random Response 3.12-11

3.12.3 Automatic Output for Modal Frequency and Random Response 3.12-18

3.12.4 Case Control Deck and Parameters for Modal Frequency and Random Response 3.12-18

3.12.5 Optional Diagnostic Output for FEER 3.12-19

3.12.6 The APPEND Feature 3.12-19

3.13 MODAL TRANSIENT RESPONSE 3.13-1

3.13.1 DMAP Sequence for Modal Transient Response 3.13-1

3.13.2 Description of DMAP Operations for Modal Transient Response 3.13-10

3.13.3 Automatic Output for Modal Transient Response 3.13-17

3.13.4 Case Control Deck and Parameters for Modal Transient Response 3.13-17

3.13.5 Optional Diagnostic Output for FEER 3.13-18

3.13.6 The APPEND Feature 3.13-18

3.13.7 The CØNTINUE Feature 3.13-19

3.14 NORMAL MODES WITH DIFFERENTIAL STIFFNESS 3.14-1

3.14.1 DMAP Sequence for Normal Modes with Differential Stiffness 3.14-1

3.14.2 Description of DMAP Operations for Normal Modes with Differential Stiffness 3.14-10

3.14.3 Automatic Output for Normal Modes with Differential Stiffness 3.14-18

3.14.4 Case Control Deck and Parameters for Normal Modes with Differential Stiffness 3.14-19

3.14.5 Optional Diagnostic Output for FEER 3.14-21

3.14.6 The APPEND Feature 3.14-21

3.15 STATIC ANALYSIS USING CYCLIC SYMMETRY 3.15-1

3.15.1 DMAP Sequence for Static Analysis using Cyclic Symmetry 3.15-1

Section		Page No.
	3.15.2 Description of DMAP Operations for Static Analysis using Cyclic Symmetry	3.15-9
	3.15.3 Case control Deck and Parameters for Static Analysis using Cyclic Symmetry	3.15-15
3.16	NORMAL MODES ANALYSIS USING CYCLIC SYMMETRY	3.16-1
	3.16.1 DMAP Sequence for Normal Modes Analysis using Cyclic Symmetry	3.16-1
	3.16.2 Description of DMAP Operations for Normal Modes Analysis using Cyclic Symmetry	3.16-7
	3.16.3 Automatic Output for Normal Modes Analysis using Cyclic Symmetry	3.16-11
	3.16.4 Case Control Deck and Parameters for Normal Modes Analysis using Cyclic Symmetry	3.16-12
	3.16.5 Optional Diagnostic Output for FEER	3.16-14
	3.16.6 The APPEND Feature	3.16-14
3.17	STATIC HEAT TRANSFER ANALYSIS	3.17-1
	3.17.1 DMAP Sequence for Static Heat Transfer Analysis	3.17-1
	3.17.2 Description of DMAP Operations for Static Heat Transfer Analysis	3.17-7
	3.17.3 Case Control Deck and Parameters for Static Heat Transfer Analysis	3.17-12
3.18	NONLINEAR STATIC HEAT TRANSFER ANALYSIS	3.18-1
	3.18.1 DMAP Sequence for Nonlinear Static Heat Transfer Analysis	3.18-1
	3.18.2 Description of DMAP Operations for Nonlinear Static Heat Transfer Analysis	3.18-6
	3.18.3 Case Control Deck and Parameters for Nonlinear Static Heat Transfer Analysis	3.18-9
3.19	TRANSIENT HEAT TRANSFER ANALYSIS	3.19-1
	3.19.1 DMAP Sequence for Transient Heat Transfer Analysis	3.19-1
	3.19.2 Description of DMAP Operations for Transient Heat Transfer Analysis	3.19-8
	3.19.3 Case Control Deck and Parameters for Transient Heat Transfer Analysis	3.19-13
3.20	MODAL FLUTTER ANALYSIS	3.20-1
	3.20.1 DMAP Sequence for Modal Flutter Analysis	3.20-1
	3.20.2 Description of DMAP Operations for Modal Flutter Analysis	3.20-10
	3.20.3 Output for Modal Flutter Analysis	3.20-18

Section		Page No.
	3.20.4 Case Control Deck and Parameters for Modal Flutter Analysis	3.20-18
	3.20.5 The APPEND Feature	3.20-20
3.21	MODAL AEROELASTIC RESPONSE	3.21-1
	3.31.1 DMAP Sequence for Modal Aeroelastic Response	3.21-1
	3.21.2 Description of DMAP Operations for Modal Aeroelastic Response	3.21-11
	3.21.3 Case Control Deck and Parameters for Modal Aeroelastic Response	3.21-19
	3.21.4 The APPEND Feature	3.21-21
4.	PLOTTING	
4.1	PLOTTING	4.1-1
4.2	STRUCTURE PLOTTING	4.2-1
	4.2.1 General Rules	4.2-2
	4.2.1.1 Rules for Free-Field Card Specifications	4.2-2
	4.2.1.2 Plot Request Packet Card Format	4.2-2
	4.2.1.3 Plot Titles	4.2-2a
	4.2.2 Plot Request Packet Card Descriptions	4.2-2a
	4.2.2.1 SET Definition Cards	4.2-3
	4.2.2.2 Cards Defining Parameters	4.2-4
	4.2.2.3 PLØT Execution Card	4.2-12
	4.2.2.4 Examples of PLØT Cards	4.2-14a
	4.2.3 Summary of Structure Plot Request Packet Cards	4.2-16
	4.2.4 Error Messages	4.2-19
4.3	X-Y OUTPUT	4.3-1
	4.3.1 X-Y Plotter Terminology	4.3-1
	4.3.2 Parameter Definition Cards	4.3-3
	4.3.2.1 Cards Pertaining to All Curves	4.3-3
	4.3.2.2 Cards Pertaining Only to Whole Frame Curves	4.3-4
	4.3.2.3 Cards Pertaining Only to Upper Half Frame Curves	4.3-6
	4.3.2.4 Cards Pertaining Only to Lower Half Frame Curves	4.3-7
	4.3.3 Command Operation Cards	4.3-9

Section — Page No.

4.3.4 Examples of X-Y Output Request Packets 4.3-17

4.3.5 Summary of X-Y Output Request Packet Cards 4.3-19

5. DIRECT MATRIX ABSTRACTION

5.1 GENERAL 5.1-1

5.2 DMAP RULES 5.2-1

5.2.1 DMAP Rules for Functional Module Instructions 5.2-1

5.2.1.1 Functional Module DMAP Statements 5.2-2

5.2.1.2 Functional Module Names 5.2-2

5.2.1.3 Functional Module Input Data Blocks 5.2-2

5.2.1.4 Functional Module Output Data Blocks 5.2-3

5.2.1.5 Functional Module Parameters 5.2-3

5.2.1.6 DMAP Compiler Options - The XDMAP Instruction 5.2-4a

5.2.1.7 Extended Error Handling Facility 5.2-4b

5.2.2 DMAP rules for Executive Operation Instructions 5.2-4b

5.2.3 Techniques and Examples of Executive Module Usage 5.2-4c

5.2.3.1 The REPT and FILE Instructions 5.2-5

5.2.3.2 The EQUIV Instruction 5.2-7

5.2.3.3 The PURGE Instruction 5.2-9

5.2.3.4 The CHKPNT Instruction 5.2-12

5.3 INDEX OF DMAP MODULE DESCRIPTIONS 5.3-1

5.4 MATRIX OPERATIONS MODULES 5.4-1

5.5 UTILITY MODULES 5.5-1

5.6 USER MODULES 5.6-1

5.7 EXECUTIVE OPERATION MODULES 5.7-1

5.8 EXAMPLES 5.8-1

5.8.1 DMAP Example 5.8-1

5.8.2 DMAP Example 5.8-2

5.8.3 DMAP Example to Use the Structure Plotter to Generate Undeformed Plots of the Structural Model 5.8-3

5.8.4 Example of DMAP to Print Eigenvectors Associated with any of the Modal Formulation Rigid Formats 5.8-4

Section — Page No.

5.8.5 Example of DMAP Using a User-Written Module 5.8-5

5.8.6 DMAP ALTER Package for Using a User-Written Auxiliary Input File Processor 5.8-7

5.8.7 DMAP to Perform Real Eigenvalue Analysis Using Direct Input Matrices 5.8-8

5.8.8 DMAP Example to Print and Plot a Topological Picture of Two Matrices 5.8-10

5.8.9 DMAP Example to Compute the r-th Power of a Matrix [Q] 5.8-11

5.8.10 Usage of UPARTN, VEC, and PARTN 5.8-13

5.8.11 DMAP Example 5.8-19

5.9 AUTOMATIC SUBSTRUCTURE DMAP ALTERS 5.9-1

5.9.1 Index of Substructure DMAP Alters 5.9-2

5.9.2 DMAP for Command: BRECØVER (Phase 3) 5.9-3

5.9.3 DMAP for Command: CØMBINE 5.9-4

5.9.4 DMAP for Utility Commands: DELETE, DESTRØY, EDIT, EQUIV, RENAME, SØFPRINT 5.9-5

5.9.5 DMAP for Substructure Plots: PLØT 5.9-6

5.9.6 DMAP for Command: RECØVER (Phase 2) 5.9-7

5.9.7 DMAP for Command: REDUCE 5.9-8

5.9.8 DMAP for Command: RUN 5.9-9

5.9.9 DMAP for External I/Ø Commands: SØFIN, SØFØUT, RESTØRE, DUMP, CHECK 5.9-10

5.9.10 DMAP for Command: SØLVE 5.9-11

5.9.11 DMAP for Command: SUBSTRUCTURE 5.9-12

5.10 SUPPLEMENTARY FUNCTIONAL MODULES 5.10-1

6. DIAGNOSTIC MESSAGES

6.1 RIGID FORMAT DIAGNOSTIC MESSAGES 6.1-1

6.1.1 Displacement Approach Rigid Formats 6.1-1

6.1.1.1 Rigid Format Error Messages for Static Analysis 6.1-1

6.1.1.2 Rigid Format Error Messages for Static Analysis with Inertia Relief 6.1-1

6.1.1.3 Rigid Format Error Messages for Normal Mode Analysis . 6.1-2

6.1.1.4 Rigid Format Error Messages for Static Analysis with Differential Stiffness 6.1-2

Section			Page No.
		6.1.1.5 Rigid Format Error Messages for Buckling Analysis	6.1-3
		6.1.1.6 Rigid Format Error Messages for Piecewise Linear Analysis	6.1-3
		6.1.1.7 Rigid Format Error Messages for Direct Complex Eigenvalue Analysis	6.1-4
		6.1.1.8 Rigid Format Error Messages for Direct Frequency and Random Response	6.1-4
		6.1.1.9 Rigid Format Error Messages for Direct Transient Response	6.1-4
		6.1.1.10 Rigid Format Error Messages for Modal Complex Eigenvalue Analysis	6.1-5
		6.1.1.11 Rigid Format Error Messages for Modal Frequency and Random Response	6.1-5
		6.1.1.12 Rigid Format Error Messages for Modal Transient Response	6.1-5
		6.1.1.13 Rigid Format Error Messages for Normal Modes with Differential Stiffness	6.1-6
		6.1.1.14 Rigid Format Error Messages for Static Analysis Using Cyclic Symmetry	6.1-6
		6.1.1.15 Rigid Format Error Messages for Normal Modes Using Cyclic Symmetry	6.1-7
	6.1.2	Heat Approach Rigid Formats	6.1-8
		6.1.2.1 Rigid Format Error Messages for Static Heat Transfer Analysis	6.1-8
		6.1.2.2 Rigid Format Error Messages for Nonlinear Static Heat Transfer Analysis	6.1-8
		6.1.2.3 Rigid Format Error Message for Transient Heat Transfer Analysis	6.1-8
	6.1.3	Aero Approach Rigid Format	6.1-9
		6.1.3.1 Rigid Format Error Messages for Modal Flutter Analysis	6.1-9
		6.1.3.2 Rigid Format Error Messages for Modal Aeroelastic Response	6.1-9
6.2	NASTRAN SYSTEM AND USER MESSAGES		6.2-1
	6.2.1	Preface Messages	6.2-2
	6.2.2	Executive Module Messages	6.2-17
	6.2.3	Functional Module Messages	6.2-19
7.	NASTRAN DICITONARY		
7.1	NASTRAN DICTIONARY		7.1-1

List of Pages Changed, Replaced, or Added

Page No.	Page No.	Page No.
Cover Page	2.4-90a and 2.4-90b	2.7-23
v - xvi	2.4-94a and 2.4-94b	2.7-27 and 2.7-28
1.2-1	2.4-102a and 2.4-102b	2.7-30 thru 2.7-32
1.3-6b	2.4-116a	3.2-1 thru 3.2-10
1.3-7	2.4-116c	3.2-12 and 3.2-13
1.7-9 and 1.7-10	2.4-138i and 2.4-138j	3.2-13a and 3.2-13b
1.9-3 and 1.9-4	2.4-141	3.2-15 and 3.2-16
1.9-9 and 1.9-10	2.4-143	3.3-1 thru 3.3-8
1.10-36 thru 1.10-38	2.4-182a	3.3-10 and 3.3-11
1.10-40 and 1.10-41	2.4-182c thru 2.4-182ℓ	3.3-13
1.10-41a and 1.10-41b	2.4-184b thru 2.4-184d	3.4-1 thru 3.4-7
1.10-42 thru 1.10-47	2.4-245	3.4-9 thru 3.4-11
1.10-51	2.4-247	3.4-14a and 3.4-14b
1.10-51a thru 1.10-51d	2.4-254c	3.4-15
1.10-52 thru 1.10-55	2.4-264e	3.4-17
1.10-55a and 1.10-55b	2.4-264g and 2.4-264h	3.5-1 thru 3.5-10
1.10-56 thru 1.10-58	2.4-271	3.5-12
1.10-73	2.4-273	3.5-14 and 3.5-15
1.10-75	2.4-275	3.6-1 thru 3.6-11
1.11-1 thru 1.11-21	2.4-277	3.6-13
2.2-1 thru 2.2-22	2.4-292a and 2.4-292b	3.7-1 thru 3.7-14
2.3-2	2.4-302a and 2.4-302b	3.8-1 thru 3.8-8
2.3-2a and 2.3-2b	2.4-303	3.8-12
2.3-3	2.4-305	3.9-1 thru 3.9-10
2.3-3a and 2.3-3b	2.5-8	3.9-20
2.3-4	2.5-8a and 2.5-8b	3.10-1 thru 3.10-9
2.3-8a and 2.3-8b	2.5-9	3.10-13
2.3-1a and 2.3-9b	2.7-2	3.10-18 and 3.10-19
2.3-18	2.7-2a and 2.7-2b	3.11-1 thru 3.11-8
2.3-20b	2.7-3	3.11-10 thru 3.11-12
2.3-25	2.7-6	3.11-14
2.3-31a and 2.3-31b	2.7-6a and 2.7-6b	3.12-1 thru 3.12-11
2.3-46a and 2.3-46b	2.7-11a and 2.7-11b	3.12-13 thru 3.12-17
2.3-47	2.7-15	3.12-19
2.4-8bb thru 2.4-8bi	2.7-15a and 2.7-15b	3.13-1 thru 3.13-10
2.4-36a	2.7-16a thru 2.7-16h	3.13-12 thru 3.13-16
2.4-36e	2.7-17	3.13-18 and 3.13-19
2.4-62c	2.7-20	3.14-1 thru 3.14-10
2.4-62e	2.7-20a and 2.7-20b	3.14-12 and 3.14-13

List of Pages Changed, Replaced, or Added

Page No.	Page No.	Page No.
3.14-15 thru 3.14-17	5.1-1	5.9-7a and 5.9-7b
3.14-21	5.2-1	5.9-8 thru 5.9-11
3.15-1 thru 3.15-17	5.2-1a and 5.2-1b	5.9-11a and 5.9-11b
3.16-1 thru 3.16-7	5.3-1	5.9-12
3.16-9 and 3.16-10	5.4-19	5.9-12a
3.16-10a and 3.16-10b	5.4-19a and 5.4-19b	5.10-1 thru 5.10-4
3.16-14	5.4-20	6.2-13
3.17-1 thru 3.17-6	5.4-20a and 5.4-20b	6.2-24 and 6.2-25
3.18-1 thru 3.18-5	5.5-1	6.2-25a
3.19-1 thru 3.19-7	5.5-13 and 5.5-14	6.2-26a and 6.2-26b
3.20-1 thru 3.20-11	5.5-31	6.2-28
3.20-11a and 3.20-11b	5.5-37 and 5.5-38	6.2-28c and 6.3-28d
3.20-12 thru 3.20-17	5.5-41	6.2-28h and 6.2-28i
3.20-19 and 3.20-20	5.5-49 and 5.5-50	6.2-28& thru 6.2-28q
3.21-1 thru 3.21-22	5.9-1 thru 5.9-3	6.2-33h
4.1-2	5.9-3a and 5.9-3b	6.2-33ha and 6.2-33hb
4.1-4	5.9-4	6.2-33i
4.2-11	5.9-4a and 5.9-4b	6.2-41 thru 6.2-43
4.2-11a and 4.2-11b	5.9-5	6.2-43a and 6.2-43b
4.2-17	5.9-5a and 5.9-5b	6.2-44 thru 6.2-55
4.3-3 and 4.3-4	5.9-6 and 5.9-7	7.1-1 thru 7.1-68
4.3-19		

1.2 GRID POINTS

1.2.1 Grid Point Definition

Geometric grid points are defined on GRID bulk data cards by specifying their coordinates in either the basic or a local coordinate system. The implicitly defined basic coordinate system is rectangular, except when using axisymmetric elements. Local coordinate systems may be rectangular, cylindrical, or spherical. Each local system must be related directly or indirectly to the basic coordinate system. The CØRD1C, CØRD1R and CØRD1S cards are used to define cylindrical, rectangular and spherical local coordinate systems, respectively, in terms of three geometric grid points which have been previously defined. The CØRD2C, CØRD2R and CØRD2S cards are used to define cylindrical, rectangular and spherical local coordinate systems, respectively, in terms of the coordinates of three points in a previously defined coordinate system.

Six rectangular displacement components (3 translations and 3 rotations) are defined at each grid point. The local coordinate system used to define the directions of motion may be different from the local coordinate system used to locate the grid point. Both the location coordinate system and the displacement coordinate system are specified on the GRID card for each geometric grid point. The orientation of displacement components depends on the type of local coordinate system used to define the displacement components. If the defining local system is rectangular, the displacement system is parallel to the local system and is independent of the grid point location as indicated in Figure 1a. If the local system is cylindrical, the displacement components are in the radial, tangential and axial directions as indicated in Figure 1b. If the local system is spherical, the displacement components are in the radial, meridional, and azimuthal directions as indicated in Figure 1c. Each geometric grid point may have a unique displacement coordinate system associated with it. The collection of all displacement coordinate systems is known as the global coordinate system. All matrices are formed and all displacements are output in the global coordinate system. The symbols T1, T2 and T3 on the printed output indicate translations in the 1, 2 and 3-directions, respectively, for each grid point. The symbols R1, R2 and R3 indicate rotations (in radians) about the three axes.

Provision is also made on the GRID card to apply single-point constraints to any of the displacement components. Any constraints specified on the GRID card will be automatically used for all solutions. Constraints specified on the GRID card are usually restricted to those degrees of

freedom that will not be elastically constrained and hence must be removed from the model in order to avoid singularities in the stiffness matrix.

The GRDSET card is provided to avoid the necessity of repeating the specification of location coordinate systems, displacement coordinate systems, and single-point constraints, when all, or many, of the GRID cards have the same entries for these items. When any of the 3 items are specified on the GRDSET card, the entries are used to replace blank fields on the GRID card for these items. This feature is useful in the case of such problems as space trusses where one wishes to remove all of the rotational degrees of freedom or in the case of plane structures where one wishes to remove all of the out-of-plane or all of the in-plane motions.

Scalar points are defined either on an SPØINT card or by reference on a connection card for a scalar element. SPØINT cards are used primarily to define scalar points appearing in constraint equations, but to which no structural elements are connected. A scalar point is implicitly defined if it is used as a connection point for any scalar element. Special scalar points, called "extra points", may be introduced for dynamic analyses. Extra points are used in connection with transfer functions and other forms of direct matrix input used in dynamic analyses and are defined on EPØINT cards.

*GRIDB is a variation of the GRID card that is used to define a point on a fluid-structure interface (see Section 1.7).

1.2.2 Grid Point Sequencing

The best decomposition and equation solution times are obtained if the grid points can be sequenced in such a manner as to create matrices having small numbers of active columns (see Section 2.2 of the Theoretical Manual for a discussion of active columns and the decomposition algorithm). The decomposition time is proportional to the sum of the squares of the number of active columns in each row of the triangular factor. The equation solution time (forward/backward substitution) is proportional to the number of nonzero terms in the triangular factor.

In selecting the grid point sequencing it is not important to find the best sequence, rather it is usually quite satisfactory to find a good sequence, and to avoid bad sequences that create unreasonably large numbers of active columns. For many problems a sequence which will result in a band matrix is a reasonably good choice, but not necessarily the best. Also, sequences which result in small numbers of columns with nonzero terms are usually good but not necessarily the best.

may have nonlinear material characteristics in Piecewise Linear Analysis: CTRMEM, CTRIA1, CTRIA2, CQDMEM, CQUAD1, CQUAD2.

The element coordinate systems for the triangular and quadrilateral elements are shown in Figure 5. The integers 1, 2, 3, and 4 refer to the order of the connected grid points on the connection cards defining the elements. A similar connection scheme for elements with mid-side grid points would be defined by six integers on the connection card. The angle θ is the orientation angle for anisotropic materials.

Average values of element forces are calculated for all plate elements (except the CTRPLT1) having a finite bending stiffness. The element forces for the CTRPLT1 are calculated at the corners and centroid of the element. The positive directions for plate element forces in the element coordinate system are shown in Figure 6a. The following element forces per unit of length, either real or complex, are output on request:

1. Bending moments on the x and y faces.
2. Twisting moment.
3. Shear forces on the x and y faces.

The CQDMEM2 is the only membrane element for which element forces are calculated. The positive directions for these forces are shown in Figure 3b, and the force output has the same interpretation as the force output for the shear palen discussed previously.

Average values of the membrane stresses are calculated for the triangular and quadrilateral membrane elements, with the exception of the CQDMEM1 and CTRIM6 elements. For the CQDMEM1 element, in which the stress field varies, the stresses are evaluated at the intersection of diagonals (in a mean plane if the element is warped.) For the CTRIM6 element, the stresses are calculated at the corners and centroid of the element. The positive directions for the membrane stresses are shown in Figure 6b. The stresses for the CQDMEM2 element are calculated in the material coordinate system. The material coordinate system is defined by the material orientation angle on the CQDMEM2 card. The stresses for all other membrane elements are calculated in the element coordinate system.

The following real membrane stresses are output on request:

1. Normal stresses in the x and y directions
2. Shear stress on the x face in the y direction
3. Angle between the x-axis and the major principal axis
4. Major and minor principal stresses
5. Maximum shear stress

Only the normal stresses and shearing stress are available in the complex form.

If an element has bending stiffness, the average stresses are calculated on the two faces of the plate for homogeneous plates and at two specified points on the cross-section for other plate elements. The distances to the specified points are given on the property cards. The positive directions for these fiber distances are defined according to the right-hand sequence of the grid points specified on the connection card. These distances are identified in the output and must be nonzero in order to obtain nonzero stress output. The same stresses are calculated for each of the faces as are calculated for membrane elements.

In the case of composite plate elements (CTRIA1, CTRIA2, CQUAD1 and CQUAD2 only), the stresses mentioned above can also be requested in a material coordinate system which is specified on a MAT1 or MAT2 card. In place of the fibre distances, the output in this case identifies the specified material coordinate system as well as an output code. This latter code is set to 1 or 2 according as the material x-axis or the y-axis is chosen as the reference axis.

The element stresses in material coordinate system computed above (for CTRIA1, CTRIA2, CQUAD1 and CQUAD2 elements) can also be requested at the connected grid points. These stresses (at grid points) are obtained by interpolation. The output code in this case is set to (10*N + projection code) where N is the number of independent points used in the interpolation and the projection code is an integer which is set to 1, 2 or 3 according as the material x-axis, y-axis or the z-axis is normal to projection.

In the case of composite plate elements (CTRIA1, CTRIA2, CQUAD1 and CQUAD2 only), strains and curvatures are also output on request. The options available and the output formats are similar to those available in the case of stresses as described above.

The quadrilateral elements are intended for use when the surfaces are reasonably flat and the geometry is nearly rectangular. For these conditions, the quadrilateral elements eliminate the modeling bias associated with the use of triangular elements, and quadrilaterals give more

accurate results for the same mesh size. If the surfaces are highly warped, curved or swept, triangular elements should be used. Under extreme conditions quadrilateral elements will give results that are considerably less accurate than triangular elements for the same mesh size. Quadrilateral elements should be kept as nearly square as practicable, as the accuracy tends to deteriorate as the aspect ratio of the quadrilateral increases. Triangular elements should be kept as nearly equilateral as practicable, as the accuracy tends to deteriorate as the angles become obtuse and as the ratio of the longest to the shortest side increases.

1.3.6 Axisymmetric Shell Elements

The properties of axisymmetric shells can be specified with either of two elements, the conical shell (CØNEAX) or the toroidal ring (TØRDRG). However, these cannot be used together in the same model. Also available for thick shells of revolution are the axisymmetric solid elements (TRIARG, TRAPRG, TRIAAX, and TRAPAX) which are described in the next section. Thin shell (TRSHL) modeling is described in Section 1.3.12.

The properties of the conical shell element are assumed to be symmetrical with respect to the axis of the shell. However, the loads and deflections need not be axisymmetric, as they are expanded in Fourier series with respect to the aximuthal coordinate. Due to symmetry, the resulting load and deformation systems for different harmonic orders are independent, a fact that results in a large time saving when the use of the conical shell element is compared with an equivalent model constructed from plate elements. Theoretical aspects of the conical shell element are treated in Section 5.9 of the Theoretical Manual.

The conical shell element may be combined with TRIAAX and TRAPAX elements only. The existence of a conical shell problem is defined by the AXIC card. This card also indicates the number of harmonics desired in the problem formulation. Only a limited number of bulk data cards are allowed when using conical shell elements. The list of allowable cards is given on the AXIC card description in Section 2.4.2.

The geometry of a problem using the conical shell element is described with RINGAX cards instead of GRID cards. The RINGAX cards describe concentric circles about the basic z-axis, with their locations given by radii and z-coordinates as shown in Figure 7. The degrees of freedom defined by each RINGAX card are the fourier coefficients of the motion with respect to angular position around the circle. For example the radial motion, u_r, at any angle, ϕ, is described by the equation:

$$u_r(\phi) = \sum_{n=0}^{N} u_r^n \cos n\phi + \sum_{n=0}^{N} u_r^{n*} \sin n\phi \,, \qquad (1)$$

where u_r^n and u_r^{n*} are the fourier coefficients of radial motion for the n-harmonic. For calculation purposes the series is limited to N harmonics as defined by the AXIC card. The first sum in the above equation describes symmetric motion with respect to the $\phi = 0$ plane. The second sum with the "starred" (*) superscripts describes the antisymmetric motion. Thus each RINGAX data card will produce six times (N+1) degrees of freedom for each series.

cation number (in field 2 of the RINGFL data card) were 37, the internally generated grid points would have the following identification numbers:

Harmonic	Id.
0	1,000,037
1*	1,500,037
1	2,000,037
2*	2,500,037
2	3,000,037

These equivalent grid points are resequenced automatically by NASTRAN to be adjacent to the original RINGFL identification number. A RINGFL point may not be resequenced by the user.

The output from matrix printout, table printout, and error messages will have the fluid points labeled in this form. If the user wishes, he may use these numbers as scalar points for Random Analysis, X-Y plotting, or for any other purpose.

In addition to the multiple sets of points and connection cards, the NASTRAN preface also may generate constraint sets. For example if a free surface (FSLIST) is specified in a zero-gravity field, the pressures are constrained by NASTRAN to zero. For this case the internally generated set of single point constraints are internally combined with any user defined structural constraints and will always be automatically selected.

If pressures at points in the fluid (PRESPT) or gravity dependent normal displacements on the free surface (FREEPT) are requested, the program will convert them to scalar points and create a set of multipoint constraints with the scalar points as dependent variables. The constraint set will be internally combined with any user defined sets and will be selected automatically.

The PRESPT and FREEPT scalar points may be used as normal scalar points for purposes such as plotting versus frequency or time. Although the FREEPT values are displacements, scalar elements connected to them will have a different meaning than in the structural sense.

MATERIAL PREVIOUSLY ON PAGES 1.7-10 THROUGH 1.7-14 HAS BEEN DELETED.

square into two rectangles will not improve the results whereas dividing the square into four smaller squares may decrease the local error by as much as a factor of ten.

The slot portion of the cavity is limited to certain shapes because of basic assumptions in the algorithms. The cross section of the cavity normal to the axis must have a shape that is reasonably well defined by a central circular cavity having equally spaced, narrow slots. Various shapes are shown in Figure 1 in the order of increasing expected error.

It is recommended that shapes such as the cloverleaf and square cross section be analyzed with a full three dimensional technique. The assumption of negligible pressure gradient in the circumferential direction within a slot is not valid in these cases.

The harmonic orders of the solutions are also limited by the width of the slots. The harmonic number, N, should be no greater than the number of slots divided by two. The response of the higher harmonics is approximated by the slot width correction terms discussed in the NASTRAN Theoretical Manual, Section 17.1.

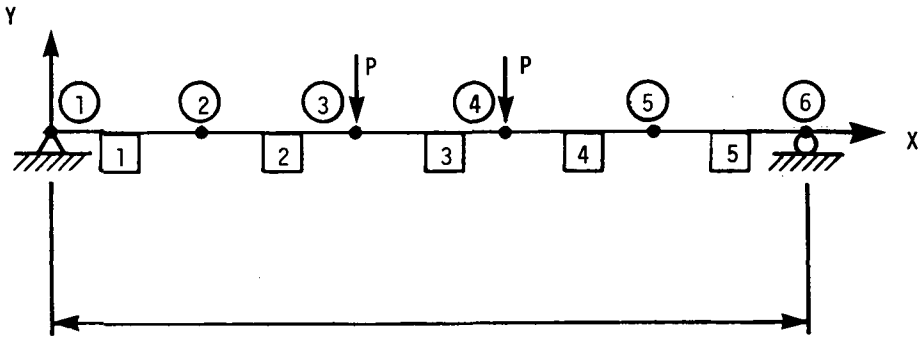
The output data for the acoustic analysis consists of the values of pressure in the displacement vector selected via the case control card "PRESSURE = i". The velocity vector components corresponding to each mode may be optionally requested by the case control card "STRESS = i", where i is the set number indicating the element numbers to be used for output, or by the words "STRESS = ALL". The "SET =" card lists the element or point numbers to be output.

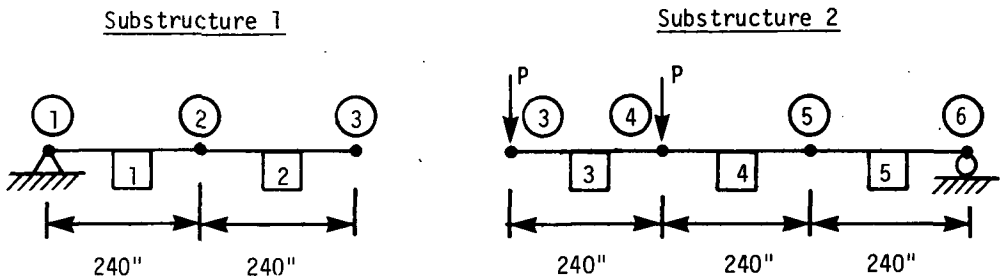
Plots of the finite element model and/or of the pressure field may be requested with the NASTRAN plot request data cards. The central cavity cross section will be positioned in the XY plane of the Basic Coordinate System of NASTRAN. The slot elements are offset from the XY plane by the width of the slot in the +Z direction. The radial direction corresponds to X and the axial direction corresponds to the Y direction. Pressures will be plotted in the Z direction for both the slot points and the central cavity points. The case control data cards for plotting are documented in the User's Manual. The PLØTEL elements are used for plotting the acoustic cavity shape. The plot request card "SET n INCLUDE PLØTEL" must be used where n is a set number.

MATERIAL PREVIOUSLY ON PAGES 1.9-4 THROUGH 1.9-7 HAS BEEN DELETED.

MATERIAL PREVIOUSLY ON PAGE 1.9-9 HAS BEEN DELETED.

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY.





(2) Grid Point Numbers

[3] Element Numbers

$E = 30 \times 10^6$ psi

$I = 500$ in^4

P = 1000 lbs

Figure 1. Manual substructuring problem.

1.10.2 Automated Multi-Stage Substructuring

Large and complex structural analysis problems can be solved for static and dynamic response and/or normal mode shapes using the automated multi-stage substructuring features of NASTRAN. As with all substructuring approaches, the user subdivides the intended model into a set of smaller, more elementary partitions called basic substructures. The components of the whole structure can be modeled independently, checked for accuracy, and then assembled automatically all at once or in stages to form a composite model representing the whole structure for final solution.

In order to effectively employ this automated substructuring capability of NASTRAN for static and normal modes analyses, the user should gain an overall understanding of the basic program design concepts, the data base on which it operates, and the control functions provided. These topics are discussed in the sections which follow. Suggestions, recommendations, and cautions to be observed when using automated substructuring are presented in Section 1.10.2.6.

A detailed description of the substructuring control cards and a summary of pertinent bulk data cards is provided in Section 2.7 of this manual. A detailed description of each of these bulk data cards is included alphabetically along with all other bulk data cards in Section 2.4. The basic design concepts used in developing this automated substructuring capability are described below. The theory is presented in Section 4.6 of the Theoretical Manual.

1.10.2.1 Basic Concepts

Automated substructuring analysis is available for use with NASTRAN Rigid Fromats 1, 2, 3, 8, and 9. This provides capability for static analysis, static analysis with inertial relief for unsupported structures, and normal modes, frequency response, and transient response analyses. The capability allows an unlimited number of substructures to be combined and/or reduced in any sequence desired. Each substructure is represented by its mass, stiffness, and damping matrices. A reduction in size or condensation of these matrices is accomplished using the Guyan reduction technique or reduction to normal or complex modal coordinates.

Although the NASTRAN substructuring system may be used for small and moderate size problems, several features are available to accommodate very large problems. The most important of these features is the automated data base management system used to maintain the Substructure Operating

File (SØF) on which all pertinent matrix and substructural loading data and associated control files are stored. This SØF carries all the information needed from run to run throughout a substructuring analysis.

Processing automated substructuring analyses is subdivided into three phases similar to those described earlier for manual substructuring. The usual analysis proceeds as follows. First, several separate Phase 1 executions are performed, one for each basic substructure. Second, one or more Phase 2 executions may be performed. In a Phase 2 run, any number of substructure reductions and/or combinations, resulting in higher level (meaning more complex) pseudostructures, may be performed. Phase 2 processing may be halted at any stage of model assembly and restarted in a subsequent Phase 2 execution. The results at each step in the operation are stored on the SØF so as to be available for subsequent execution. The final steps of a Phase 2 operation would be the solution step for the highest level structure and the data recovery steps with limited output capability (displacements, forces of constraint, modal energies, and applied loads only) for any lower level substructure. Complete and detailed data recovery for the basic substructures must be obtained by separate Phase 3 executions, one for each basic substructure. This level of data recovery may inlcude any or all of the NASTRAN output normal for a non-substructure analysis.

Automated substructuring allows each basic substructure to be defined independently. This concept is represented by three key features of the system.

1. There are no restrictions as to duplication of grid point or element identification numbers, load sets, individual coordinate systems, etc. All data for a given substructure is associated with an assigned unique name for that structure. The only data restriction is one of proper modeling, i.e., common boundaries require grid points to be located at the same point in space for each connecting substructure.

2. No substructure may appear as a component of another substructure more than once; and no degrees of freedom within a substructure may be connected ("combined") to other degrees of freedom in that same substructure except by multipoint constraints imposed at the solution step operation.

3. All pertinent substructure data are stored on the SØF, an expandable direct access file. This file may be selectively edited and/or dumped to tape and transmitted to another user who may have need for the data. Provision is made for automated tape conversion among

CDC, IBM, and UNIVAC computers to facilitate such data transmittal between different users. Use of this file is described in Section 1.10.2.4.

Control of the automated substructuring system is obtained through the use of linguistic commands, similar to those of Case Control. These commands are placed in the Substructure Control Deck shown in Figure 2. This Substructure Control Deck is situated between the Executive Control and Case Control Decks.

Each substructure control command is automatically translated into appropriate DMAP ALTER cards to augment the requested Rigid Format sequence. The user may also include his own DMAP ALTER commands, or he may modify a previously defined DMAP sequence. A description of how the user may interface with this NASTRAN-generated substructuring DMAP is presented in Section 2.7.2. Listings of the DMAP ALTERs generated by each substructure command are presented in Section 5.9. Descriptions of the corresponding modules provided for substructuring are found in the NASTRAN Programmer's Manual.

1.10.2.2 Substructure Operations and Control Functions

User control of the automated multi-stage substructuring system is obtained via the Substructure Control Deck commands. The key terms used to describe these commands and their functions are defined in Table 16. A summary of the substructuring command options is presented in Table 17. Some of these commands require specific bulk data cards which are listed for easy reference in Table 18. The user should also refer to Section 2.7 for a complete description of the Substructure Control Deck commands and to Section 2.3 for detailed descriptions of the corresponding bulk data cards.

The operation and control functions of automated substructuring analysis are best illustrated and explained using the "tree" structure presented in Figure 3. This figure defines the geneology of all the component substructures used in building a final model. Basic substructures are created at the Phase 1 level. Substructures "A," "B," and "E" are shown in solid boxes indicating they were formed from actual data deck submittals and are physically different models. The dotted boxes are called "image" substructures and are the result of an EQUIVALENCE operation rather than an actual Phase 1 data deck submittal. The EQUIVALENCE operation defines a new substructure which is a duplicate of an existing substructure and automatically creates all equivalent lower level component substructures. Thus, space is saved on the data files by eliminating storage of redundant matrix data. A four-bladed propeller, for example, could be seen to consist of four

identical components and, hence, only one need by explicitly modeled. The other three blades could be defined solely by using the EQUIVALENCE command.

The image substructures exist in name only. Note in Figure 3 that the names of the image structures are identical to the equivalent parent structure, with the exception of a prefix character. The new names would be created automatically by NASTRAN with the use of the PREFIX subcommand to EQUIVALENCE. These new prefixed names would then be used to reference the appropriate component substructure as if it were created independently.

Note, the term "lower level" refers to the less complex of the component substructures which are used to create a higher level, or more complex substructure.

From the user point of view, all substructures shown in Figure 3, with either solid or dotted boxes, are separate and distinct substructures. They may have different applied loads, boundary conditions, and responses. For example, though only A, B, and E represent actual Phase 1 executions, Phase 3 data recovery executions may be made for A, B, E, XA, XB, YA, YB, YXB, and YE, each of which generally would have different results.

The CØMBINE command (see Table 17) with its numerous subcommands, offers flexibility in the assembly of substructures into a higher level substructure. The CØMBINE capability allows component substructures to be translated, rotated, and/or symmetrically transformed via mirror image transformation for proper positioning in space.

For example, the right wing of an aircraft is first modeled and an EQUIVALENT operation is performed to define an identical duplicate wing. Then, in the CØMBINE operation, a SYMTRANSFØRM is applied so that the wing now appears as the actual left wing (a mirror image of the right wing), and a TRANSFØRM is applied to properly position it on the left side of the aircraft. Caution is advised in that the symmetry transformation (SYMTRAN) is always applied to the component in its own basic coordinate system before the usual translation and rotation (TRANS) for final positioning (see Section 4.6 of the Theoretical Manual).

The REDUCE command causes a Guyan reduction to be performed on an existing substructure. The user specifies which degrees of freedom are to be retained using the BDYC and BDYS (or BDYS1) bulk data cards provided. The degrees of freedom retained are all called boundary degrees of freedom although they all need not ever appear on the boundary with another substructure. Obviously, all degrees of freedom eventually needed for boundary connections must be retained, i.e., they must not be reduced out. However, care must be taken to retain in this boundary set

all the appropriate degrees of freedom needed to represent the dominant displacement patterns for accurate calculation of eigenvalues and eigenvectors for normal modes analyses.

The MREDUCE and CREDUCE commands provide a modal synthesis capability to automated multi-stage substructuring. With these commands the user defines boundary degrees of freedom to identify degrees of freedom retained as physical coordinates. The remaining degrees of freedom are replaced by a smaller set of normal (MREDUCE) or complex (CREDUCE) generalized modal coordinates. MREDUCE may be used when real symmetric mass and stiffness matrices are used to define the model. CREDUCE provides a general modal reduction capability when damped modes are desired or complex or unsymmetric matrices are present.

The user may also define constraints for the structure to be applied only for the purpose of calculating the modes. BDYC and BDYS (or BDYS1) bulk data cards are used to define these degrees of freedom and are requested by the subcommand FIXED.

Note that for both the REDUCE and MREDUCE substructure commands, the damping matrices, B and K4, and the load vectors, P, are transformed to the reduced set of coordinates. The reduced substructures may be processed with any of the other substructure operations. However, substructures generated with the complex modal reduction, CREDUCE, may not be processed with any commands requiring real arithmetic, namely REDUCE, MREDUCE, or SØLVE with Rigid Formats 1, 2, 3, or 9.

As many EQUIVALENCE, CØMBINE, REDUCE, MREDUCE, or CREDUCE commands as desired may be used in one or more Phase 1 or Phase 2 executions. However, only one SØLVE command is allowed in any single Phase 2 execution, and the SØLVE command is not allowed in Phase 1 executions. As indicated in the definitions of Table 1, the SØLVE command requests a solution for structural response to applied static loads (Rigid Formats 1 and 2), the calculation of normal modes (Rigid Format 3), or structural response to frequency dependent or time dependent loads (Rigid Formats 8 and 9) of the substructure named in the command.

The RECØVER command is used in Phase 2 to recover the solution data for successively lower level substructures. Only the displacements, forces of constraint, modal energies, and applied loads can be selectively output for any component substructure during these Phase 2 operations. The BRECØVER command is then used in a Phase 3 execution to obtain all the detail response output normally provided by NASTRAN for each desired basic substructure. The command, MRECØVER, is used to recover mode shape data for modal reduced substructures.

Using the PLØT command, only undeformed plots may be requested in a Phase 2 execution. Deformed plots can only be obtained from a Phase 3 execution.

The user controls each step in the analysis by specifying the appropriate commands to be executed and the substructure names, such as A, B, YC, etc. (see Figure 3), of each substructure to be used in that step.

To reduce the potential for input error and to simplify the bookkeeping tasks, all specific references to loadings and grid points for connection, boundary sets, and constraints, etc. are made with respect to the basic substructure name only. For these reasons, no component substructure may be used more than once while building the solution structure. That is, every component named in any substructure must be unique. If the same component substructure is to be used more than once, e.g., identical components are to be used to create the full model, the EQUIVALENCE operation should be used as described earlier to assign unique names to all substructures comprising that component.

Substructure names are allowed no more than eight alphanumeric characters. Notice in the EQUIVALENCE operation shown in Figure 3, the required subcommand PREFIX generates an additional character which is placed ahead of the existing name as a prefix to the parent substructure name. Care must be taken with successive EQUIV operations to monitor the growth of image substructure names so as not to exceed the eight-character limit. If the limit is exceeded, the right-most character will be truncated. Therefore, it is possible to inadvertently create duplicate substructure names as more prefixes are added. It is recommended, therefore, that the entire tree structure for the analysis be prepared ahead of time to help avoid these problems. This preplanning also will be an invaluable aid to the task of data preparation and proper sequencing of the individual steps in the analysis.

1.10.2.3 Input Data Checking and Interpretation of Output

The automated substructuring system provides several methods for input data checking, diagnostic output, and substructure-oriented data output.

A principal facility for input data checking is the RUN=DRY command. This option allows the user to validate the command structure and data without actually performing the more time consuming matrix operations. Assuming the input is found to be consistent, the run may be resubmitted with the RUN=GØ option to complete the matrix processing.

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY.

Also available is a RUN=STEP option (the default option) which first checks the data and then executes the matrix operations one step at a time. If errors are detected in the data, the matrix operations are skipped and the remainder of the processing sequence is executed as a DRY run only.

The user also is allowed to process only selected matrix data. If, for example, after having assembled the solution structure, new loading conditions are to be added or normal modes are desired but the mass matrix is not available, the necessary sequence of matrix operations can be requested using the RUN=GØ option to process the new load or mass matrix data only. The ØPTIØNS command, described in Section 2.7, causes selective processing of mass (M), damping (B) or (K4), stiffness (K), or load (P) data only. The PA option (load append) is used when new Phase 1 load vectors are to be added to the set of existing load vectors. Note that when using the ØPTIØNS command, if existing substructure data items are to be recreated (see Table 19), the old data must be removed using the EDIT or DELETE commands as described in the next section. This is necessary because only one item of a given type may be allowed on the SØF for any particular substructure.

All the relevant substructuring data generated by the program may be displayed with the ØUTPUT command described in Section 2.7. The CØMBINE, REDUCE, MREDUCE, and CREDUCE operations involve specification of grid point and degree of freedom data related to the basic substructures involved. The automatically generated or manually specified connectivities are critical to the CØMBINE operation. Using these output options, the information can be obtained to explicitly verify all connectivities. The REDUCE, MREDUCE, and CREDUCE operations require the user to specify the degrees of freedom to be retained. These also are identified by basic substructure grid point numbers. If desired, these same output options can be used to obtain lists of all the retained degrees of freedom of the resulting pseudostructure to help verify the resulting model. The following paragraphs describe examples of the possible output that can be requested.

The table shown below may be used to verify all substructure connectivities. This, and the other examples of diagnostic output to be described later, are reporductions of actual problem output requested under the CØMBINE command used to create a pseudostructure named WINDMILL from component substructures RING and VANR.

SUMMARY ØF PSEUDØSTRUCTURE CØNNECTIVITIES

INTERNAL PØINT NØ	INTERNAL DØF NØ	DEGREES ØF FREEDØM	RING	VANR
34	67	12	RING 146	
35	69	12	RING 147	
36	71	12	RING 148	
37	73	12	RING 103	VANE 1
38	75	12	RING 106	VANE 2
39	77	12	RING 109	VANE 3
50	79	12		VANE 13
41	81	12		VANE 14

The column heading "INTERNAL PØINT NØ" references the equivalent of internally generated "grid points" for the resulting pseudostructure. "INTERNAL DØF NØ" references the internally sequenced first degree of freedom (row or column number) in the matrices of WINDMILL for the designated internal grid point. "DEGREES ØF FREEDØM" references the component degrees of freedom in the global coordinate system of the assembled structure associated with the internal grid point. In the example above, the following may be observed:

1. Degrees of freedom 1 and 2 from grid point 109 of basic substructure RING and grid point 3 of basic component VANE in substructure VANE are connected and assigned to internal point 39 of pseudostructure WINDMILL.
2. Displacement components 1 and 2 at internal point 39 are the 77th and 78th degrees of freedom for the matrices of WINDMILL.

Note that only basic substructure names appear in association with grid points. In this example, RING and VANR are the substructures referenced by the CØMBINE command. VANR exists as a higher level substructure with VANE as the basic substructure.

Substructure items EQSS and BGSS, which are created by the CØMBINE or REDUCE operations, are helpful in checking the results of these substructure commands. They are stored along with the other items on the SØF (see Table 19) and can be accessed at any time with the SØFPRINT command. The display of these items, however, is normally requested by the ØUTPUT subcommand of either the CØMBINE, REDUCE, MREDUCE, or CREDUCE commands at the time of their execution.

The EQSS item provides data for each basic substructure relating external or basic substructure grid point numbers to pseudostructure internal grid point numbers. In the example shown below, degrees of freedom 1 and 2 of grid point 102 of basic substructure RING have been assigned to internal grid point 2 of pseudostructure WINDMILL.

EQSS ITEM FØR SUBSTRUCTURE WINDMILL CØMPØNENT RING

GRID PØINT ID	INTERNAL PØINT NØ	CØMPØNENT DØF
102	2	12
105	4	12
108	6	12
111	8	12
114	11	12
117	13	12
120	15	12
123	17	12
126	20	12
129	22	12
132	24	12
135	26	12
138	29	12
141	31	12
144	33	12
147	35	12

In addition to the above data for each basic substructure, the EQSS item also contains summary data for the resultant pseudostructure. A sample is shown below.

EQSS ITEM - SCALAR INDEX LIST FOR SUBSTRUCTURE WINDMILL

INTERNAL PØINT ID	INTERNAL SIL ID	CØMPØNENT DØF
2	3	12
5	9	12
8	15	12
11	21	12
14	27	12
17	33	12
20	39	12
23	45	12
26	51	12
29	57	12
32	63	12
35	69	12

In the above table, the relationships of the internal grid point numbers to the internal degree of freedom numbers (referenced as "INTERNAL SIL ID") and to the component degrees of freedom are defined for pseudostructure WINDMILL. The internal degrees of freedom are referenced as a Scalar Index List (SIL) because all substructure problem degrees of freedom are converted to scalar points for purposes of Phase 2 processing. If desired for special purposes, therefore, these internal degrees of freedom may be referenced as scalar points for use with any of the nonsubstructuring Bulk Data cards to be input to the SØLVE step operations in Phase 2.

The EQSS items and the summary of pseudostructure connectivities table are related. For example, by cross referencing each table it can be seen that internal grid point 35 of substructure WINDMILL has degrees of freedom 1 and 2 assigned to it. These degrees of freedom numbers in the SIL list are 69 and 70, respectively, and these degrees of freedom come from grid point 147 of basic substructure RING.

Special treatment is required for the EQSS item for substructures which are modal reduced. For example, if basic substructure A is reduced to MA using MREDUCE or CREDUCE, the EQSS for MA indicates that pseudostructure MA has two component substructures, A and MA. The EQSS for component A contains the boundary point definitions. The EQSS for component MA contains definitions for the newly created modal coordinates. Inertia relief coordinates are assigned Grid Point ID's of 1 through 6 to MA, and flexible mode coordinates are assigned GRID Point ID's of 101 through 100+N where N is the number of flexible modes used. Refer to Sections 4.6.2 and 18 of the Theoretical Manual and Section 2.7 of this manual for definitions of the modal coordinates.

The modal degrees of freedom of component substructure MA (both inertia relief and flexible mode coordinates) may be referenced for application of constraints in the SØLVE operation. They may also be referenced as boundary coordinates in subsequent reduction operations.

CØMBINE or reduction operations also create the BGSS item. A sample is shown below. The BGSS item contains internal grid point locations for the substructure model. In this example, the BGSS item displays all the internal point numbers for the pseudostructure WINDMILL along with its corresponding location coordinates in that pseudostructure's basic system. The "CSTM ID NØ" column indicates the existence (if any) of local coordinate systems associated with those internal points. If the entry is "0", the displacement components will be in that pseudostructure basic

BGSS ITEM FØR SUBSTRUCTURE WINDMILL

INTERNAL PØINT ID	CSTM ID NØ	C Ø Ø R D I N A T E S		
		X1	X2	X3
1	0	-0.500000E+01	0.100000E+02	0.E+00
2	0	-0.500000E+01	0.150000E+02	0.E+00
3	0	0.E+00	0.100000E+02	0.E+00
4	0	0.E+00	0.150000E+02	0.E+00
5	0	0.500000E+01	0.100000E+02	0.E+00
6	0	0.500000E+01	0.150000E+02	0.E+00
7	0	0.750000E+01	0.750000E+01	0.E+00
8	0	0.100000E+02	0.100000E+02	0.E+00
9	0	0.125000E+02	0.125000E+02	0.E+00
10	0	0.100000E+02	0.500000E+01	0.E+00

system. Otherwise, they will be in a local system which may be verified with the optional printout of the coordinate system transformations (a 3x3 matrix of direction cosines) as stored in the "CSTM" item for that pseudostructure.

Modal coordinates are indicated in the BGSS by a CSTM ID NØ of -1 and a coordinate location of X1 = 0.0, X2 = 0.0, and X3 = 0.0. The CSTM ID NØ of -1 is NASTRAN convention for a scalar point. Note that scalar points will never be combined with any other points using the automatic CØMBINE operation.

Another useful output item is the SUBSTRUCTURE ØPERATING FILE TABLE ØF CØNTENTS (TØC), as shown in Figure 4. In this figure, the substructure tree has been added to the TØC output to help visualize the sample problem. This output is obtained with the command: SØFPRINT TØC. The TØC lists by name all substructures that reside on the SØF, lists the current items available for each substructure, and provides a set of pointers which describe the hierarchy of substructure relationships. The SØF pointer scheme is described by defining the individual column headings shown in the TØC:

TYPE Defines the substructure type:

B - basic substructure

C - combined substructure

R - Guyan reduced substructure

M - real modal reduced substructure

CM - complex modal reduced substructure

Any of the above types will have prefix "I" if it is an image substructure resulting from an EQUIV operation.

SS Points to a substructure which is secondary to the current substructure. In the case where many secondary substructures have been EQUIVed to a single primary substructure, the SS entries form a chain starting with the primary substructure and ending with an SS pointer of zero.

PS Points to the substructure which is primary to the current substructure. PS is non-zero for secondary substructures only.

LL Points to a substructure at the next lower (simpler) level to the current substructure.

CS Points to a substructure which has been combined with the current substructure. The CS entries form a circular chain.

HL Points to the substructure at the next higher (complex) level to the current substructure.

All normal NASTRAN output for each basic substructure, primary or image substructure, is available via a Phase 3 execution. Also, certain output may be recovered in Phase 2 for any or all of the substructures in the solution structure's tree. However, this output is limited to displacements, applied loads, and forces of single-point constraint. The output requested in Phase 2 is labeled by both the pseudostructure and its component basic substructure names.

Some discussion of the forces of constraint, which may be requested as output in both Phase 2 and Phase 3, is required. The Phase 3 calculations for forces of constraint are computed in the normal NASTRAN convention (refer to Section 3.7 of the Theoretical Manual). In a Phase 2 execution, however, the forces of constraint include additional terms. The equations used for the calculations are shown below and are identified by rigid format application. In these equations, {Q} are the forces of constraint, {P} are the applied loads, {u} is the displacement vector, [K]

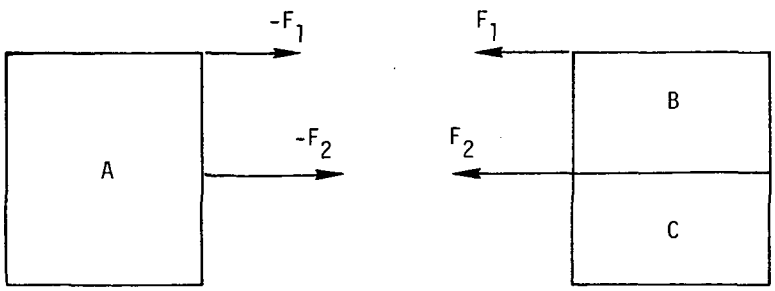
is the stiffness, [B] is the damping, [M] is the mass, ω^2 are eigenvalues from a real modes analysis, and ρ are complex eigenvalues from a complex modal reduction.

Rigid Format	Equation for Forces of Constraint
1 and 2	$\{Q\} = [K]\{u\} - \{P\}$
3	$\{Q\} = [K]\{u\} - [M][\omega^2]\{u\}$
3	$\{Q\} = [K]\{u\} + [B][\rho]\{u\} + [M][\rho^2]\{u\}$
8 and 9	$Q = [K]\{u\} + [B]\{\dot{u}\} + [M]\{\ddot{u}\} - \{P\}$

The force vectors $\{Q\}$ contain all the terms due to

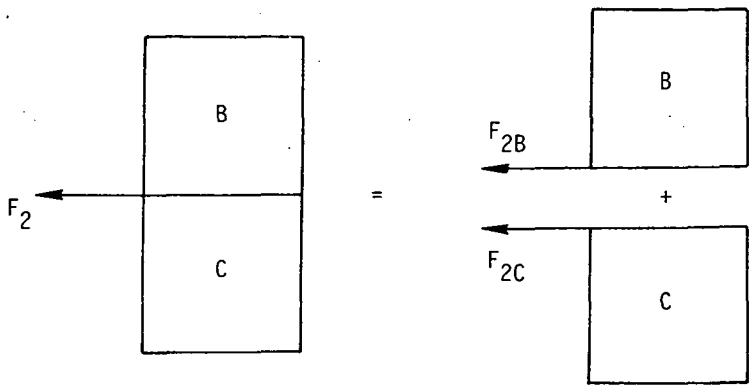
1. Inertia forces
2. Damping forces
3. Single-point constraints
4. Multipoint constraints
5. Forces transferred from other connected substructures
6. Residual forces due to computer round-off

The equations presented above for calculation of forces of constraint provide especially useful information, i.e., the forces of substructure interconnection as shown below.



Substructure A Substructure BC

Forces F_1 and F_2, recovered as forces of constraint for substructure A and for pseudostructure BC, represent the forces of interconnectivity. Force F_2 represents the sum of two component forces, one from each component substructure B and C, acting at their common grid point. The separate contributions to F_2 from each B and C may be determined by using the RECØVER command for the component substructures B and C individually, as shown below.



1.10.2.4 Substructure Operating File (SØF)

The data required for each basic substructure and for all subsequent combinations of substructures are stored on the Substructure Operating File (SØF). The SØF data are stored in direct access format on disk or drum during a NASTRAN execution. These data may also be stored on tape between runs for backup storage or for subsequent input to other computers. Schematic diagrams of data flow for each of the three phases of execution are given in Figure 5.

The SØF file, which contains the data items listed in Table 19, is used to communicate all required data between each phase of operation and between each step of the Phase 2 operation. Thus, the user is allowed to develop his analysis in separate steps without requiring the checkpoint/restart feature of NASTRAN. A Phase 1 run is required to build each basic substructure and place its data on the SØF prior to any Phase 2 reduction or combination using that substructure. Using that data, component pseudostructures may be assembled in stages from these basic substructures and added later to other component substructures already on the SØF file. Also, the same SØF may be used to build the data files for more than one solution structure at a time.

Once the final solution model is established, the solution may be obtained and results recovered for any level, component pseudo- or basic substructure. However, detail element stresses and element forces or support reactions specified with the basic substructure can be recovered only in Phase 3. These Phase 3 results may be recovered either by using the original data deck or by restarting from a checkpointed Phase 1 execution.

The SØF is structured as a single logical file used to store all data necessary for a complete multi-stage substructuring analysis. However, the SØF may actually reside on from one to ten physical files. These physical files would be chained together to form the single logical file for use in the analysis of larger problems. The figure below shows the basic arrangement of an SØF on disk or drum.

Output requests in Case Control are honored only if there is a PRINT subcommand under the *RECØVER command in the Substructure Control Deck. If a RECØVER command with a PRINT subcommand* is used, the Case Control should be identical (except for output requests) to that used to obtain the solution being printed.

The following requirements must be satisfied by the Case Control Deck in Phase 3:

1. Constraint sets (MPC, SPC) must be identical to those used in Phase 1 for this substructure.
2. The subcase definition for load set IDs must be identical to those used in Phase 1 for this substructure including those for appended loads, if any. All load definitions must appear in the order generated.
3. The subcase definition for the Phase 3 output requests for solution vectors generated in Phase 2 must be merged with the above subcase definition for load set IDs. Note, the ØLØAD output requested in Phase 3 will correspond to the load factors defined during Phase 2 solution, not those defined by Phase 3 Case Control.

The number of Phase 3 subcases required is the maximum of those defined in either Phase 1 or Phase 2. All output requests will correspond to the Phase 2 subcase sequence, starting with the first subcase defined in Phase 3. It is essential to assign the same thermal and element deformation loadings to the same subcases in both Phase 1 and Phase 2 in order to provide the correct load correction data to the Phase 3 output processing of element forces and stresses.

1.10.2.6 User Aids for Automated Substructuring Analysis

The following suggestions, recommendations, and cautions should be considered when using automated multi-stage substructuring. The automated substructuring capability offers the user flexibility in the performance of an analysis. To take advantage of this capability, it is recommended that the new user carefully review both the Theoretical and User's Manual sections on substructuring and execute the sample problem which is documented in the following Section 1.10.2.7.

Simulation Analyses - The user is advised to simulate large structural model analyses with simplified models using the substructuring system. Using this technique, all deck structures, including operational commands and control of the SØF, may be tested using small matrices at low cost. In addition, any special features such as user DMAP operations may be tested at this time.

Reduction - Generally, the most economical analyses may be performed using relatively small basic substructures or by performing significant reductions in Phase 1 (using ØMIT or ASET bulk data cards). When using Guyan reduction, either reduce most degrees of freedom (many more than half) or very few degrees of freedom (many less than half) if possible. Note that the resulting matrices are usually dense and, hence, may take up more space on the SØF than the original matrices.

When using modal reduction use the FIXED set to help approximate the expected solution mode shapes. Also, remember that when inertia relief shapes are requested, six shapes are created. However, if the problem is not fully three dimensional, some of these shapes may be null, and the resulting singularities must be accounted for in subsequent operations. Note that flexible mode shapes which introduce singularities, such as rigid body shapes at zero frequency, are automatically excluded from assignment to the reduced substructure. The rigid body shapes are not needed because the boundary points, by definition, must provide the rigid body description of the structure.

Load Append - In the event that additional new loading conditions are required, the LØDAPP (Load Append) features may be used. This feature, described in Section 2.7, allows the user to avoid performing redundant Phase 2 computations.

Singularities - Selective grid point degrees of freedom are often singular in stiffness (as rotations about a vector normal to a plate) and may be constrained in Phase 1. However, if these grid points are later transformed to a new output coordinate system during a CØMBINE operation, the singularity may be re-introduced to the problem. NASTRAN substructuring transforms grid point degrees of freedom in groups of three translations and three rotations. Thus, if one or more translational and/or rotational degrees of freedom exist for a grid point and a general transformation (not 90°, 180°, or 270°) is applied, 3 translational and/or rotational degrees of freedom will exist for the resulting structure for that grid point. However, the stiffness matrix will be singular, and this must be considered in subsequent operations. For example, in future reduction operations some of these degrees of freedom must be kept in the boundary set so that the interior point stiffness matrix is non-singular. The extraneous singularities are finally removed at the SØLVE operation using SPCS or MPCS cards.

User Modes - The user may define a substructure in terms of modal data obtained from another source such as test data for example. To use this capability the user creates a Phase 1 job with an MREDUCE command as shown below.

```
SUBSTRUCTURE PHASE1
(SØF control cards)
NAME = name
MREDUCE name
  NAME = r-name
  USERMØDES = j
    .
    .
    .
```

Two options are allowed, j = 1 or 2. If j = 1, a structural model is defined as usual with bulk data cards. However, the modal data, i.e. the eigenvalue data and mode shape data, are defined by using direct input tables and matrices in the bulk data deck. Table LAMAR must be input using DTI cards using the format specified for the LAMA data block described in the Programmer's Manual. Only the modal mass and frequency (HZ) need be defined in LAMAR. The mode shapes must be input using DMI cards and the matrix name PHIS. The PHIS matrix must be the NASTRAN F-set size, i.e. the fixed degrees of freedom must be described with null rows.

If j = 2, the model is completely defined with matrix data. As is done for j = 1, a LAMAR table and PHIS matrix must be input. In addition, a matrix named QSM, which contains the modal reaction forces for degrees of freedom fixed in mode extraction, is input using DMI cards. Matrix QSM has one row for every degree of freedom (as does PHIS) and one column for every mode. Null row entries exist for degrees of freedom not fixed in mode extraction. Note that the number of modes must exceed the number of degrees of freedom for this option (see Section 18 of the Theoretical Manual). For the j = 2 option, the bulk data deck must include Grid cards to define the degrees of freedom represented by the rows of PHIS and QSM. In addition, a dummy element should be included in the data deck so that NASTRAN parameter values are properly set. The user may also input boundary mass and stiffness matrices. These data may be defined using CØNMi, CELASi, and GENEL cards, in which case dummy elements are not required, or may be input using DMI or DMIG cards. For the latter case, the user must insert the correct Executive Control Deck alters to equivalence the input mass and stiffness data to MGG and KGG respectively.

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY.

Boundary set definitions are required using BDYC, BDYS and BDYS1 cards for both user mode options. Note that all degrees of freedom defined for the j = 2 options must be specified as boundary degrees of freedom.

Old Modes and Old Boundaries - The ØLDMØDES and ØLDBØUND subcommands to the MREDUCE command allow the user to modify the new, modal coordinate substructure without performing all new calculations.

The ØLDMØDES subcommand requests that the mode shapes and frequencies computed in a previous MREDUCE be reused to define the modified structure. This is possible because all modes computed are saved on the SØF even if they are not currently used to describe the substructure. The user may request the previously used set of modes or a new subset of the previously calculated modes by his use of the NMAX or RANGE subcommands. Use of OLDMODES alone (without ØLDBØUND) implies that a new boundary set is to be defined for the reduced substructure. Use of this subcommand requires the additional subcommands BØUNDARY and NMAX or RANGE.

The ØLDBØUND subcommand requests that the boundary set definition not change for the modification to the substructure. For this case, a new set of modal data will be computed. Use of this subcommand requires the additional subcommands METHØD, NMAX or RANGE, and optionally FIXED, RNAME, and RGRID.

The use of both ØLDMØDES and ØLDBØUND implies only a change in the number of modes used from the previously computed set of modes. The use of both commands requires only a new NMAX or RANGE card as additional subcommands.

When using these subcommands the user must EDIT conflicting data from the SØF. Refer to the descriptions of MREDUCE and CREDUCE in Section 2.7 for details. Also note that both ØLDMØDES and ØLDBØUND are subcommands for MREDUCE, but only ØLDMØDES is allowed for CREDUCE. The equivalent operation of ØLDBØUND for CREDUCE requires complete redefinition of the reduced substructure.

Solution Items - It should be remembered that due to the data base protection features, at no time are there any SØF items destroyed by NASTRAN without a specific user command in the Substructure Control Deck. In addition, NASTRAN does not allow more than one substructure item (see Table 19) to exist for each substructure at any one time. As a result, some operations such as a repeated SØLVE might require the user to manually edit out previously generated solution data items or any recovered solution data items before the operation could be repeated. That is, SØLN

and UVEC items (the load factor or eigenvalue data tables and displacement vectors respectively) created in an earlier SØLVE operation should be deleted if a new solution with new loads or frequency range is desired for the same substructure. These same items must also be edited out from each lower level substructure for which the new solution data will be recovered. SØLN and UVEC items are also created by MRECØVER and must be deleted prior to a SØLVE and RECØVER for the same structure.

By using the EQUIVALENCE operation to create an identical structure, a new solution may be obtained for the same structure without deleting the older solution data items, as required in the example above.

Structural Design Considerations - Substructures which may change due to design iterations should be combined with other structures as late in the sequence of CØMBINE operations as possible. This will minimize the cost of creating a new solution structure. Also, if the design iteration changes are minor and their impact on other substructures in the model can be neglected, then RECØVER operations need be performed only from the lowest level of substructure affected by the changes. Frequently, these design changes can be evaluated using only the Phase 3 recovery calculations. Of course, care must be taken to maintain compatibility with the degree of freedom list defining the solution displacement vector. That is, the boundary grid points and connections should not be changed.

Table 16. Definitions of Substructure Terminology.

Basic Substructure	-	A structure formulated from finite elements in Phase 1.
Boundary Set	-	Set of degrees of freedom to be retained in a reduce operation.
Combine Operation	-	Merge two or more structures by connecting related degrees of freedom. The matrix elements for connected degrees of freedom are added to produce the combined structure matrices, and the substructure load vectors are processed and stored for subsequent combination at solution time.
Component Substructure	-	Any basic or pseudostructure comprising a part of an assembled substructure.
Connection Set	-	Set of grid points and their component degrees of freedom to be connected in adjoining structures.
Equivalence Operation	-	The creation of a secondary substructure equivalent to a primary substructure. Also creates image substructures back to the basic substructure level
Image Substructure	-	A substructure equivalent to an existing component substructure. May have different applied loads and/or solution vectors but has identical stiffness and mass matrices. Image substructures are automatically created as a result of an equivalence operation.
Phase (1, 2, or 3)	-	Basic steps required for multi-stage substructure processing with NASTRAN - creation, combination, reduction, solution and recovery, and detail data recovery.
Primary Substructure	-	Any basic substructure or any substructure resulting from a combine or reduce operation.
Pseudostructure	-	A combination of component substructures.
Reduce Operation	-	Structural matrix and load vector Guyan or modal reduction process to obtain smaller matrices.
Secondary Substructure	-	A substructure created from an equivalence operation.
SØF	-	Substructure Operating File. Contains all data necessary to define a structure at any stage, including solutions.
Solution Structure	-	The resulting substructure to be used in the solve operation.
Solve Operation	-	To obtain solutions using the present structural matrices and user-defined input data.

Table 17. Summary of Substructure Commands.

Phase and Mode Control	
# SUBSTRUCTURE	- Defines execution phase (1, 2, or 3)
NAME*	- Specifies Phase 1 substructure name
SAVEPLØT	- Requests plot data be saved in Phase 1
ØPTIØNS	- Defines matrix options (K, B, K4, M, P, or PA)
RUN	- Limits mode of execution (DRY, GØ, DRYGØ, STEP)
# ENDSUBS	- Terminates Substructure Control Deck

SØF Controls	
# SØF	- Assigns physical file for storage of the SØF
PASSWØRD*	- Protects and ensures access to correct file
SØFØUT or SØFIN	- Copies SØF data to or from an external file
PØSITIØN	- Specifies initial position of input file
NAMES	- Specifies substructure name used for input
ITEMS	- Specifies data items to be copied in or out
SØFPRINT	- Prints selected items from the SØF
DUMP	- Dumps entire SØF to a backup file
RESTØRE	- Restores entire SØF from a previous DUMP operation
CHECK	- Checks contents of external file created by SØFØUT
DELETE	- Deletes out selected groups of items from the SØF
EDIT	- Edits out selected groups of items from the SØF
DESTRØY	- Destroys all data for a named substructure and all the substructures of which it is a component

Manditory Control Cards

* Required Subcommand

Table 17. Summary of Substructure Commands (continued).

Substructure Operations	
CØMBINE	- Combines sets of substructures
NAME*	- Names the resulting substructure
TØLERANCE*	- Limits distance between automatically connected grids
CØNNECT	- Defines sets for manually connected grids and releases
ØUTPUT	- Specifies optional output results
CØMPØNENT	- Identifies component substructure for special processing
TRANSFØRM	- Defines transformations for named component substructures
SYMTRANSFØRM	- Sepcifies symmetry transformation
SEARCH	- Limits search for automatic connects
EQUIV	- Creates a new equivalent substructure
PREFIX*	- Prefix to rename equivalenced lower level substructures
REDUCE	- Reduces substructure matrices
NAME*	- Names the resulting substructure
BØUNDARY*	- Defines set of retained degrees of freedom
RSAVE	- Indicates the decomposition product of the interior point stiffness matrix is to be saved on the SØF
ØUTPUT	- Specifies optional output requests
MREDUCE	- Reduces substructure matrices using a normal modes transformation
NAME*	- Names the resulting substructure
BØUNDARY*	- Defines set of retained degrees of freedom
FIXED	- Defines set of constrained degrees of freedom for modes calculation
RNAME	- Specifies basic substructure to define reference point for inertia relief shapes
RGRID	- Specifies grid point in the basic substructure to define reference point for inertia relief shapes. Defaults to origin of basic substructure coordinate system
METHØD	- Identifies EIGR Bulk Data card
RANGE	- Identifies frequency range for retained modal coordinates
NMAX	- Identifies number of lowest frequency modes for retained modal coordinates
ØLDMØDES	- Flag to identify rerunning problem with previously computed modal data
ØLDBØUND	- Flag to identify rerunning problem with previously defined boundary set

* Required Subcommand

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY.

Table 17. Summary of Substructure Commands (continued).

Substructure Operations	
USERMØDES	- Flag to indicate modal data have been input on bulk data
ØUTPUT	- Specifies optional output requests
RSAVE	- Indicates the decomposition product of the interior point stiffness matrix is to be stored on the SØF.
CREDUCE	- Reduces substructure matrices using a complex modes transformation
NAME*	- Names the resulting substructure
BØUNDARY*	- Defines set of retained degrees of freedom
FIXED	- Defines set of constrained degrees of freedom for modes calculation
METHØD	- Identifies EIGC Bulk Data card
RANGE	- Identifies frequency range of imaginary part of the root for retained modal coordinates
NMAX	- Identifies number of lowest frequency modes for retained modal coordinates
ØLDMØDES	- Flag to identify rerunning problem with previously computed modal data
GPARAM	- Specifies structural damping parameter
ØUTPUT	- Specifies optional output requests
RSAVE	- Indicates the decomposition product of the interior point stiffness matrix is to be stored on the SØF
MRECØVER	- Recovers mode shape data from an MREDUCE or CREDUCE operation
SAVE	- Stores modal data on SØF
PRINT	- Stores modal data and prints data requested
SØLVE	- Initiates substructure solution (statics, normal modes, frequency response, or transient response)
RECØVER	- Recovers Phase 2 solution data
SAVE	- Stores solution data on SØF
PRINT	- Stores solution and prints data requested
BRECØVER	- Basic substructure data recovery, Phase 3
PLØT	- Initiates substructure undeformed plots

* Required Subcommand

Table 18. Substructure Bulk Data Card Summary.

Bulk Data Used By Substructure Commands REDUCE, MREDUCE, and CREDUCE
BCYC - Combination of substructure boundary sets of retained degreed of freedom or fixed degrees of freedom for modes calculation
BDYS - Boundary set definition
BDYS1 - Alternate boundary set definition
Bulk Data Used By Substructure Command CØMBINE
CØNCT - Specifies grid points and degrees of freedom for manually specified connectivities - will be overridden by RELES data
CØNCT1 - Alternate specification of connectivities
RELES - Specifies grid point degrees of freedom to be disconnected - overrides CØNCT and automatic connectivities
GTRAN - Redefines the output coordinate system grid point displacement sets
TRANS - Specifies coordinate systems for substructure and grid point transformations
Bulk Data Used by Substructure Command SØLVE
LØADC - Defines loading conditions for static analysis
MPCS - Specifies mulitpoint constraints
SPCS - Specifies single-point constraints
SPCS1 - Alternate specification of single-point constraints
SPCSD - Specifies enforced displacements for single-point constraints
DAREAS - Specifies dynamic loadings
DELAYS - Specifies time delays for dynamic loads
DPHASES- Specifies phase lead terms for dynamic loads
TICS - Specifies transient initial conditions

Table 19. Substructure Item Descriptions.

EQSS	External grid point and internal point equivalence data
BGSS	Basic grid point coordinates
CSTM	Local coordinate system transformation matrices
LØDS	Load set identification numbers
LØAP	Load set identification numbers for appended load vectors
PLTS	Plot sets and other data required for Phase 2 plotting
KMTX	Stiffness matrix
LMTX	Decomposition product of REDUCE operation
MMTX	Mass matrix
PAPP	Appended load vectors
PVEC	Load vectors
PØAP	Appended load vectors on omitted points
PØVE	Load vectors on points omitted during matrix reduction
UPRT	Partitioning vector used in matrix reduction
HØRG	H or G transformation matrix
UVEC	Displacement vectors or eigenvectors
QVEC	Reaction force vectors
SØLN	Load factor data or eigenvalues used in a solution
LAMS	Eigenvalue data from modal reduce operation
PHIS	Eigenvector matrix
GIMS	G transformation matrix for interior points from a modal reduction
K4MX	Structural damping matrix
BMTX	Viscous damping matrix
PHIL	Left side eigenvector matrix from unsymmetric CREDUCE operation
HLFT	Left side H transformation matrix from unsymmetric CREDUCE operation

MATERIAL PREVIOUSLY ON PAGES 1.10-58 THROUGH 1.10-70 HAS BEEN DELETED.

SUBSTRUCTURE ØPERATING FILE TABLE ØF CØNTENTS

SUBSTRUCTURE NØ.	NAME	TYPE	SS	PS	LL	CS	HL	EQSS	BGSS	CSTM	LØDS	PLTS	KMTX	MMTX	PVEC	PØVE	UPRT	HØRG	UVEC	QVEC	SØLN	PAPP	PØAP	LØAP	LMTX	GIMS	PHIS	LAMS	L4MX	BMTX	PHIL	HLFT
1	VANE	B	5	0	0	3	6	2	2		2		2	2	2			2	2													
2	RING	B	0	0	0	1	6	2	2		2		2	2	2			2	2													
3	VANER	B	0	1	0	4	6	2	2		2		2	2	2			2														
4	VANEB	B	3	1	0	5	6	2	2		2		2	2	2			2														
5	VANEL	B	4	1	0	2	6	2	2		2		2	2	2			2														
6	WINDMILL	C	0	0	2	0	0	2	2		2	2	2	2	2				2	2												

SIZE ØF ITEM IS GIVEN IN PØWERS ØF TEN (0 INDICATES DATA IS STØRED IN PRIMARY)

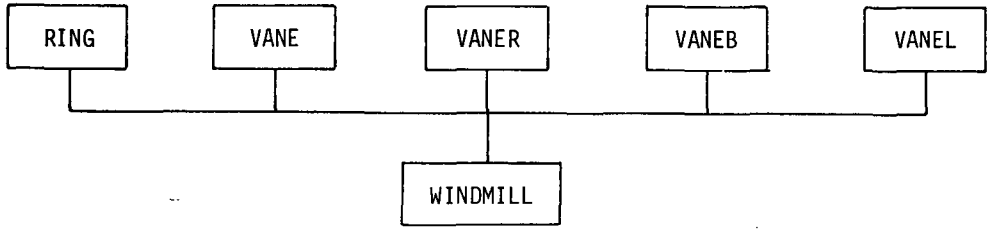
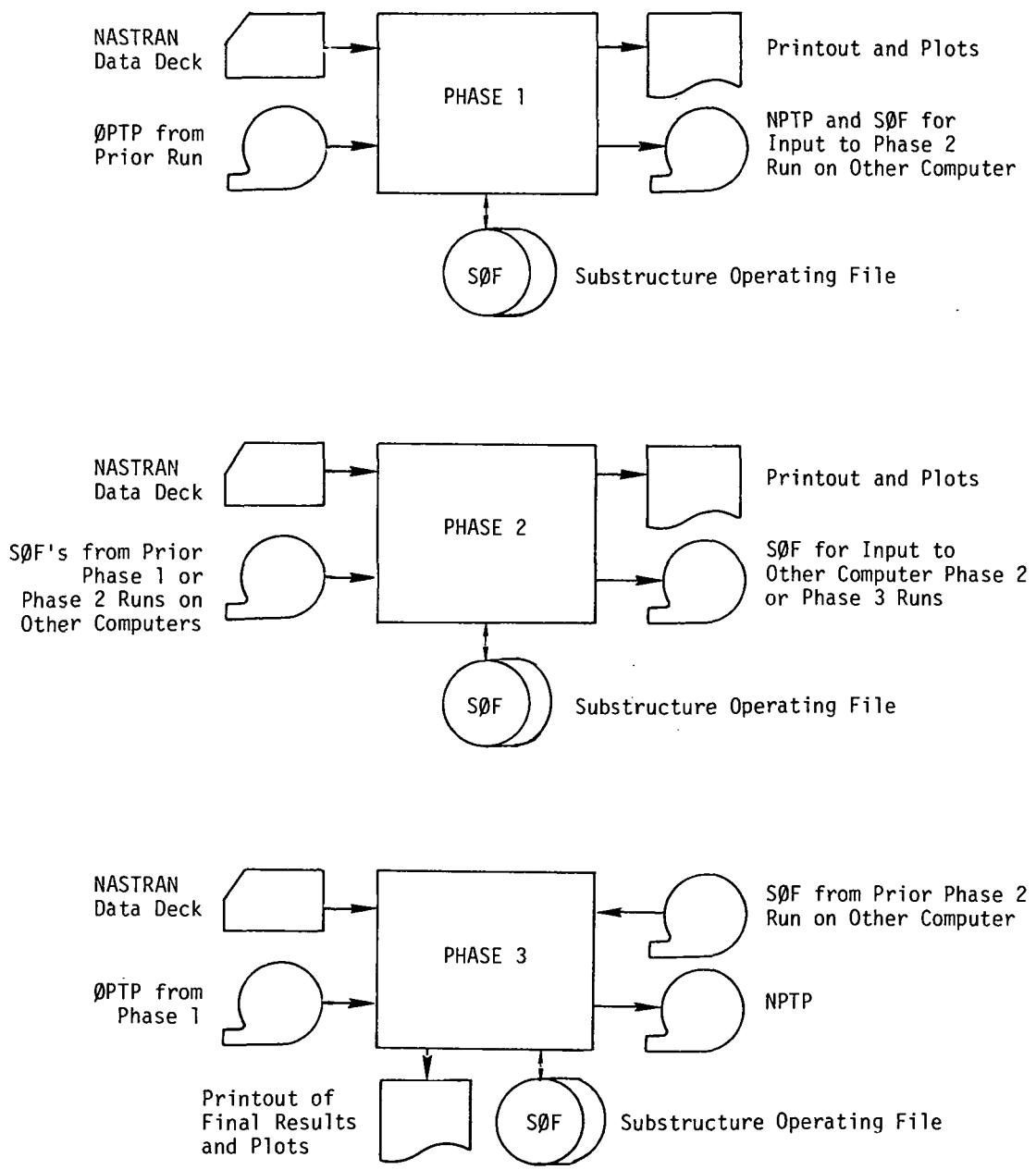


Figure 4. Sample of Substructure Operating File Table of Contents.



Note: If all processing is performed on the same computer, SØF tape output is not required. All communication may be carried out using the same SØF disk/drum throughout.

Figure 5. Data file organization for NASTRAN multi-stage substructuring.

MATERIAL PREVIOUSLY ON PAGES 1.10-75 AND 1.10-76 HAS BEEN DELETED.

1.11 AEROELASTIC MODELING

1.11.1 Introduction

The NASTRAN aeroelastic capability is intended for the study of stability and response of aeroelastic systems. It is compatible with the general structural capability, but it is not designed for use with other special capabilities such as conical shell elements, hydroelastic option, and acoustic cavity analysis. The structural part of the problem will be modeled as described in other sections of this manual. This section deals with the aerodynamic data and the connection between structural and aerodynamic elements.

Section 1.11.2 deals with the aerodynamic data. The selection of a good aerodynamic model will depend upon a knowledge of the theory (see Section 17.5 of the Theoretical Manual). Several choices of aerodynamic theory are available. All assume small amplitude sinusoidal motions. Transient aerodynamic forces are obtained by Fourier methods.

Section 1.11.3 deals with the interconnection between aerodynamic and structural degrees of freedom. The interpolation methods include both linear and surface splines. These methods are superior to high order polynomials since they tend to give smooth interpolation. They are based upon the theory of uniform beams and plates of infinite extent (see Section 17.3 of the Theoretical Manual).

Section 1.11.4 describes modal flutter analysis by the three available methods. Further details are given in the Rigid Format description (Section 3.20). A sample problem is included which shows how to analyze a simple structure for flutter using the Doublet-Lattice theory and the KE-method of flutter analysis.

Section 1.11.5 gives instructions for modal aerodynamic response analysis. This includes frequency response, transient response, and random analysis. The excitation may consist of applied forces or gusts (Doublet-Lattice theory only). The sample problem illustrates the analysis of a wing responding to enforced control surface motion.

1.11.2 Aerodynamic Modeling

Aerodynamic elements define the interaction between the structure and an airflow. Since the elements usually occur in regular arrays, the connection cards are designed to specify arrays. The grid points associated with the elements in an array are generated within the program. Spline methods are used to interpolate for aerodynamic grid point deflection in terms of structural points.

For every aerodynamic problem, basic parameters are specified on the AERØ bulk data card. A rectangular aerodynamic coordinate system must be identified. The flow is in the positive x-direction in this system. The use of symmetry (or antisymmetry) is recommended to analyze symmetric structures, to simulate ground effects, or to simulate wind tunnel walls. Any consistent set of units can be used for the dimensional quantities.

The types of elements available are shown in Table 1. Every CAERØi element must reference a PAERØi data card, which is used for additional parameters. Lists of real numbers are sometimes required, which are given on AEFACT lists. These lists may include division points (for unequal box sizes) and parameter values.

1.11.2.1 Doublet-Lattice Panels

The lifting surfaces are idealized as planes parallel to the flow. The configuration is divided into plane panels (macro-elements), each of constant dihedral. These panels are further subdivided into "boxes" (see Figure 1), which are trapezoids with sides parallel to the airflow direction. If an airfoil lies in (or nearly in) the wake of another, then the spanwise divisions should lie along the same streamline. The boxes should be arranged so that any fold or hinge lines lie along the box boundaries. The aspect ratio of the boxes should be roughly unity or less. The chord length of the boxes should be less than 0.08 times the velocity divided by the greatest frequency of interest, but no less than four boxes per chord should be used. Boxes should be concentrated near wing edges and hinge lines or any other place where downwash is discontinuous. A further discussion of the choice of models is found in Reference 1. Aerodynamic panels are assigned to groups. All panels within a group have aerodynamic interaction. The purpose of the groups is to reduce the time to compute aerodynamic matrices when it is known that aerodynamic interference is unimportant, or to allow the analyst to investigate the effects of aerodynamic interference.

Each panel is described by a bulk data CAERØ1 card. A property card PAERØ1 may be used to identify associated interference bodies. It is recommended that a body be identified if the panel is less than one body diameter from the body. The box divisions along the span are determined either by specifying the number of equal boxes (NSPAN) or the identity (LSPAN) of an AEFACT data card which gives a list of division points in terms of a fraction of the span. A similar arrangement is used in the chord direction. The locations of the two leading edge points are specified in any coordinate system (CP) defined by the user (including BASIC). The lengths of the sides are specified by the user, and they are in the airstream direction, assuring that the panel is parallel to the flow. Every panel must be assigned to some group (IGID). If all panels interact, then select IGID = 1 for all panels.

There will be many degrees of freedom associated with each aerodynamic panel. There is an aerodynamic grid point associated with each box within a given panel. These points are located at the center of each box and are automatically numbered and sequenced by the program. The lowest aerodynamic grid point number for a given panel is assigned the same number specified for the panel designation. The grid point numbers increase in increments of 1 (see CAERØ1 data card figure) over all boxes in the panel. The user must be aware of these internally generated grid points and ensure that their numbers are distinct from structural grid points. These aerodynamic points are used for output including displacements, plotting, matrix prints, etc. The local displacement coordinate system has component T1 in the flow direction and component T3 in the direction normal to the panel (the element coordinate system of CAERØ1).

1.11.2.2 Slender and Interference Bodies

The bodies are idealized as either "slender" or "interference" elements. The major purpose of the slender body elements is to account for the forces arising from the motion of the body, while the "interference" elements account for the effects of the body upon the panels and other bodies. Bodies are further classified as to the type of motion allowed. In the aerodynamic coordinate system, y and z are perpendicular to the flow. In general, bodies may move in both the y- and z-directions. Frequently, a body (e.g., a fuselage) lies on a plane of symmetry and only z (or y) motion is allowed. Thus, any model may contain z-bodies, zy-bodies, and y-bodies. One or two planes of symmetry or antisymmetry may be specified. Figure 2 shows an idealization with bodies and panels. This example case is the one used to illustrate the Doublet-Lattice program in Ref. 2. It has a body (on the midplane), a wing, pylon and nacelle.

The location of a body is specified on a CAERØ2 data card. The location of the nose and the length in the flow direction are given. The slender body elements and interference elements are distinct quantities and must be specified separately. At least two slender body elements are required for every aerodynamic body, while interference elements are optional. The geometry is given in terms of the element division points, and the width and height of the assumed elliptical cross section. The locations of the division points may be given in dimensionless units or, if the lengths are equal, only the number of elements need be specified. The semi-width of the two types of elements may be specified separately and are given in units of length. Usually the slender body semi-width is taken as zero at the nose and is a function of x, while the interference body semi-width is taken to be constant. The height-to-width ratio must be constant for each body.

These body elements are primarily intended for use with Doublet-Lattice panels. The interference elements are only intended for use with panels, while slender body elements can stand alone. Grid points will be generated only for the slender body elements. The first grid point will be assigned the ID of the body and other grid points will be incremented by one. The user must ensure that the IDs of these generated grid points are distinct from all other grid points in the model.

There are some rules about bodies which have been imposed. All z-only bodies must have lower ID numbers than zy-bodies, which in turn must have lower ID numbers than y-only bodies. The total number of interference bodies associated with a panel is limited to six. The user should be cautious about the use of associated interference bodies since they tend to increase computing time significantly.

1.11.2.3 Mach Box Theory

Mach box aerodynamics may be used to compute unsteady supersonic aerodynamic forces for a flat, isolated wing at supersonic speeds. The surface (see Figure 3) may have a leading and/or trailing edge crank (change of angle). There may be one or two adjacent (to each other) trailing edge control surfaces. The "inboard" edge (side 1-2 on the connection card) must be a plane of aerodynamic symmetry or antisymmetry.

The geometry of the planform is specified on the CAERØ3 data card. Two leading edge corners (points 1 and 4 of Figure 3) are located by the user, using any NASTRAN coordinate system. These, along with the flow direction, define the plane of the wing. Up to ten additional points are permitted to specify cranks and controls; these are dimensional quantities using a coordinate system in the plane of the wing and with origin at point 1.

The aerodynamic grid points for interconnection are in the plane of the element. The user must specify a list of x,y pairs for the wing. These are located using the coordinate system shown in Figure 3. There must be at least three points. Additional lists of at least three points are needed for each control surface which is used. The T3 component of these aerodynamic grid points is normal to the plane of the element. Interpolation for deflections and slopes at Mach box locations is done by surface spline routines within the program. Thus the control point locations can be held fixed, even when the Mach number is changed. These aerodynamic grid points will be numbered, starting with the element ID, and must be distinct from all other grid points.

The following restrictions must be satisfied:

1. The leading edge and hinge line sweepback angles must be greater than or equal to zero.
2. All control surface sides must be parallel to the flow, or else the aft point of the control surface side must be inboard of the forward point.
3. If a leading edge crank is not present, then x_5,y_5 do not have to be input.
4. If a trailing edge crank is not present, then x_6,y_6 do not have to be input.
5. A trailing edge crank cannot be located on a control surface. It must be located inboard, outboard, or exactly at the junction of the two control surfaces.
6. Points 8, 10, and 12 are used with points 7, 9, and 11 respectively to define the control surface edges. They must be distinct from points 7, 9, and 11, but they do not have to lie on the wing trailing edge. The program will calculate new points 8, 10, and 12 for the wing trailing edge. However, points 8, 10, or 12 must be located on the trailing edge if the trailing edge crank is located at the left corner of control surface one (1) or the right corner of control surface two (2) or between the two control surfaces. For example, set $x_8 = x_6$ and $y_8 = y_6$ if the crank is at the left corner of control surface one.
7. When only one control surface is present, it must be control surface one (1).
8. If control surface two (2) is not present, then x_{11},y_{11} and x_{12},y_{12} are not required as input.
9. If no control surfaces are present, then x_i,y_i (i = 7 through 12) are not required as input.

10. No aerodynamic balance for the control surfaces has been included in the Mach Box Theory.

11. The number of chordwise boxes used as input (NBØX) to the program should be carefully selected. Note that NBØX is the number of chordwise divisions from the most forward point to the most aft point on the lifting surface, as shown in Figure 4. If the maximum number of allowable boxes (200 on the main surface, 125 on each control surface) is exceeded, the program will reduce the number of chordwise boxes one at a time until the number of boxes is under the allowable limit. Expenditure of excessive computer time may occur during this process.

12. The edge 1-2 will be taken as a plane of symmetry unless SYMXZ=-1 (see AERØ data card).

1.11.2.4 Strip Theory

Modified strip theory can be used for unsteady aerodynamic forces on a high aspect ratio lifting surface. Each strip may have two or three degrees of freedom. Plunge and pitch are always used, and an aerodynamically balanced control surfaced is optional. If a control surface is present, either a sealed or an open gap may be used.

The planform (which may have several strips in one macro-element) is specified on a CAERØ4 bulk data card. A sample planform is shown in Figure 5. The user supplies the two leading edge corner locations and the edge chords as dimensional quantities. Edge chords are assumed parallel to the flow. All additional geometry (box divisions, hinge locations, etc.) are given in dimensionless units. Several CAERØ4 cards may be used if there are several surfaces or cranks.

A grid point is assigned to each strip, and will be assigned an ID starting with the macro-element ID and incrementing by one for each strip. The plunge (T3) and pitch (R2) degrees of freedom have the conventional definition. When a control surface is present, the R3 degree of freedom has a nonstandard definition, which is the relative control rotation. When interconnecting with the structure, the ordinary (surface or linear) splines can be used for T3 and R2, but a special method (see SPLINE3 data card) is used for the relative control rotation.

The parameters such as lift curve slope or lag function may be varied to account for tip effects (three-dimensional flow) and Mach number by AEFACT data card selection from PAERØ4. The AEFACT data card format used by strip theory is shown in the remarks on the PAERØ4 data card. The user may request a Prandtl-Glauert (compressibility and sweep) correction to the value of the

curve slope. The lag function depends upon the local (i.e., using the chord of the strip) reduced frequency. For incompressible flow, it is the Theordorsen function C(k). An approximate form for this function is given by

$$C(k) = \sum_{n=0}^{N} \frac{b_n}{1 - i\,\beta_n/k} \tag{1}$$

where $\beta_0 = 0$, may be selected for computing lags. The choice of parameters b_n and β_n is left to the user so that he may select values suitable for his requirement. Reference 3 gives values for various Mach numbers and aspect ratios.

1.11.2.5 Piston Theory

Piston theory in NASTRAN is a form of strip theory. The aerodynamic forces are computed from third order piston theory, which is valid for high Mach numbers $m >> 1$, or sufficiently high reduced frequency $m^2k^2 >> 1$. Although the latter condition may be met in subsonic flow, the primary application of piston theory is in supersonic flow.

The coefficients of the point pressure function (relating local pressure to local downwash) may be modified to agree with the Van Dyke theory and to account for sweepback effects. The resulting strip parameters will depend upon the wing thickness distribution and spanwise variation of initial angle of attack, which must be supplied by the user. The point pressure function is given by $Cp = -(4/m)[\overline{C}_1 + 2\overline{C}_2\, mg_x + 3C_3m^2\,(g_x^2 + \alpha_0^2)]\, v$, where

Coefficient	Van Dyke theory with Sweep	Piston Theory
$\overline{C}_1$	$m/(m^2 - s^2)^{1/2}$	1
$\overline{C}_2$	$[m^4(\gamma+1) - 4s^2\,(m^2 - s^2)]/4(m^2-s^2)^2$	$(\gamma+1)/4$
C_3	$(\gamma+1)/12$	$(\gamma+1)/12$

and where

- Cp local pressure coefficient (pressure rise divided by dynamic pressure)
- g_x derivative of airfoil semi-thickness in the flow direction
- m Mach number
- s $\sec\Lambda$, secant of sweepback angle

v unsteady dimensionless downwash

α_0 initial angle of attack

γ ratio of specific heats = 1.4

Geometry specification and interconnection points follow the same rules as for strip theory (see Section 1.11.2.4). The additional information about angle of attack and thickness is given on AEFACT data cards which are referenced by the CAERØ5 and PAERØ5 data cards. The AEFACT data card format used by piston theory is shown in the remarks on the PAERØ5 data card. If thickness integrals are input on AEFACT data cards, see the thickness integral definitions on the CAERØ5 data card.

1.11.3 The Interconnection Between Structure and Aerodynamic Models

The interpolation between the structural and aerodynamic degrees of freedom is based upon the theory of splines (Figure 6). High aspect ratio wings, bodies, or other beamlike structures should use linear splines. Low aspect ratio wings, where the structural grid points are distributed over an area, should use surface splines. Several splines can be used to interpolate to the boxes on a panel or elements on a body; however, each point can refer to only one spline. Any box or body element not referenced by a spline will be "fixed" and have no motion. For any point, especially a control surface degree of freedom, a linear relationship (like an MPC) may be specified.

For all types of splines, the user must specify the structural degrees of freedom and the aerodynamic points involved. The structural points, called the g-set, can be specified by a list or by specifying a volume in space and determining all the grid points in the volume. The degrees of freedom retained at the grid points include only the normal displacements for surface splines. For linear splines, the normal displacement is always used and, by user option, torsional rotations or slopes may be included. The global transformation at structural points is automatically applied for surface and linear splines.

The SPLINE1 data card defines a surface spline. This can interpolate for any "rectangular" subarray of boxes on a panel. For example, one spline can be used for the inboard end of a panel and another for the outboard end. The interpolated grid points (k-set) are specified by naming the lowest and highest aerodynamic grid point numbers in the area to be splined. The two methods for specifying the grid points use SET1 and SET2 data cards. A parameter DZ is used to allow some

smoothing of the spline fit. If DZ = 0 (the usual value), the spline will pass through all deflected grid points. If DZ > 0, then the spline (a plate) is attached to the grid deflections via springs, which produce a smoother interpolation that does not necessarily pass exactly through any of the points. The flexibility of the springs is proportional to DZ.

The SPLINE2 data card defines a linear spline. As can be seen from Figure 6, this is really a generalization of a simple spline to allow for interpolation over an area. It is similar to the method often used by aeronautical engineers who assume that an airfoil chord is rigid. The portion of a panel to be interpolated and the set of structural points are determined in the same manner as with SPLINE1. A NASTRAN coordinate system must be supplied to determine the axis of the spline. Since the spline has torsion as well as bending flexibility, the user may specify the ratio of flexibilities; the default value for this ratio is 1.0. The attachment flexibilities, D_z, $D_{\theta x}$, and $D_{\theta y}$, allow for smoothing, but usually all values are taken to be zero. An exception would occur if the structural model does not have slopes defined, in which case the flexibility DTHX must be infinite; the convention DTHX = -1.0 is used in this case. When used with bodies, there is no torsion and the spline axis is along the body.

There are certain cases with splines where attachment flexibility is either required or should not be used. The following special cases should be noted.

1. Two or more grid points, when projected onto the plane of the element (or the axis of a body) may have the same location. To avoid a singular interpolation matrix, a positive attachment flexibility must be used.

2. With linear splines, three deflections with the same spline y-coordinate would overdetermine the interpolated deflections since the perpendicular arms are rigid. A positive DZ is needed to make the interpolation matrix nonsingular.

3. With linear splines, two slopes (or twists) at the same y-coordinate would lead to a singular interpolation matrix. Use DTHX > 0 (or DTHY > 0) to allow interpolation.

4. For some modeling techniques, i.e., those which use only displacement degrees of freedom, the rotations of the structural model are constrained to zero to avoid matrix singularities. If a linear spline is used, the rotational constraints should not be enforced to these zero values. When used for panels, negative values of DTHX will disconnect the slope, and negative values of DTHY will disconnect the twist. For bodies, DTHY constrains the slopes since there is no twist degree of freedom for body interpolation. For a linear spline, if all of the structural points lie on a straight line, the use of infinite (negative DTHX or DTHY) rotational flexibility results in a kinematically unstable idealization.

For linear splines used with wings, the parameter DTØR should be selected as a representative value of EI/GJ.

1.11.4 Modal Flutter Analysis

The purpose of modal flutter analysis is to study the stability of an aeroelastic system with a minimum number of degrees of freedom. A prerequisite to modal flutter analysis is the calculation of an aerodynamic matrix with a transformation to modal coordinates. This operation is often very costly and care should be taken to avoid unnecessary computations. One method is to compute the modal aerodynamic matrix at a few Mach numbers and reduced frequencies and interpolate to others. Matrix interpolation is an automatic feature of the flutter rigid format. The MKAERØ1 and MKAERØ2 data cards allow the selection of parameters for the aerodynamic matrix calculation on which the interpolation is based.

The method of flutter analysis is specified on the FLUTTER bulk data card. The FLUTTER card is selected in case control by an FMETHØD card. Three methods of flutter analysis are available; K, KE and PK. These are shown in Table 2.

The K-method allows looping through three sets of parameters: density ratio (ρ/ρ_{ref}; ρ_{ref} is given on an AERØ data card); Mach number m; and reduced frequency k. For example, if the user specifies two values of each, there will be eight loops in the following order.

LØØP (CURVE)	DENS	MACH	REFREQ
1	1	1	1
2	2	1	1
3	1	1	2
4	2	1	2
5	1	2	1
6	2	2	1
7	1	2	2
8	2	2	2

Values for the parameters are listed on FLFACT bulk data cards. Usually, one or two of the parameters will have only a single value. Caution: do not set up a large number of loops; it may take an excessive time to execute.

A parameter VREF may be used to scale the output velocity. This can be used to convert from consistent units (e.g., in/sec) to any units the user may desire (e.g., knots), determined from $V_{out} = V/V_{REF}$. Another use of this parameter is to compute the flutter index, by choosing $V_{REF} = b\omega_\theta \sqrt{\mu}$.

If physical output (grid point deflections or element forces, plots, etc.) is desired rather than modal amplitudes, this data recovery can be made upon a user selected subset of the cases. The selection is based upon the velocity; the method is discussed in Section 3.20.4.

The KE-method is similar to the K method. By restricting the option, the KE-method is a more efficient K-method. The two major restrictions are that no damping (B) matrix is allowed and no eigenvector recovery is made. This means that the KE-method is not suitable for a control system, but it is a good method for producing a large number of points for the classical V-g curve. The KE-method also sorts the data for plotting. A plot request for one curve gives all of the reduced frequencies for a mode while a similar request in the K-method gives all of the modes at one k value.

The PK-method treats the aerodynamic matrices as frequency dependent springs and dampers. A frequency is estimated and the eigenvalues are found. From an eigenvalue, a new frequency is found. The convergence to a consistent root is very rapid. The major advantage of the method is that the damping values obtained at subcritical flutter conditions appear to be more representative of the physical damping. Another advantage occurs when the stability at a specified velocity is required since many fewer eigenvalue analyses are needed to find the behavior at one velocity.

The input data for the PK-method also allows looping, as in the K method. The inner loop of the user data is velocity, with Mach number and density on outer loops. Thus, the effects of varying any or all of the three parameters on one run is possible.

Subsets of flutter analysis for checking data are listed in Section 2.2.1.

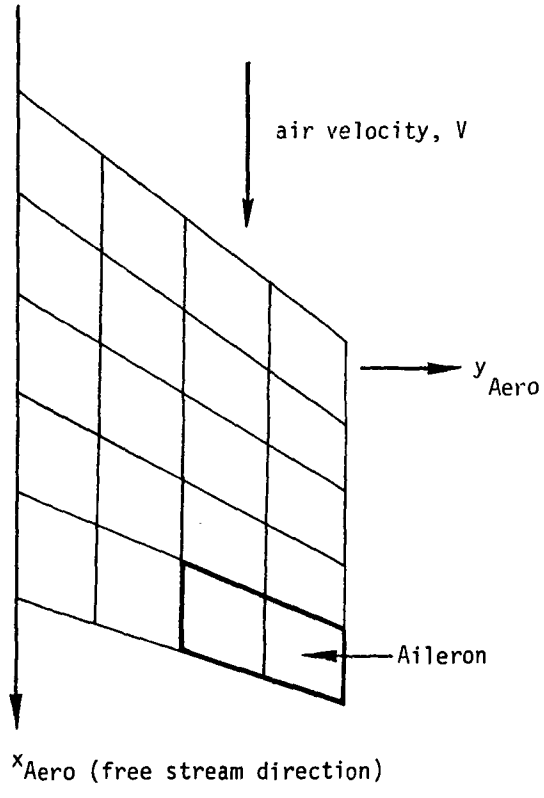
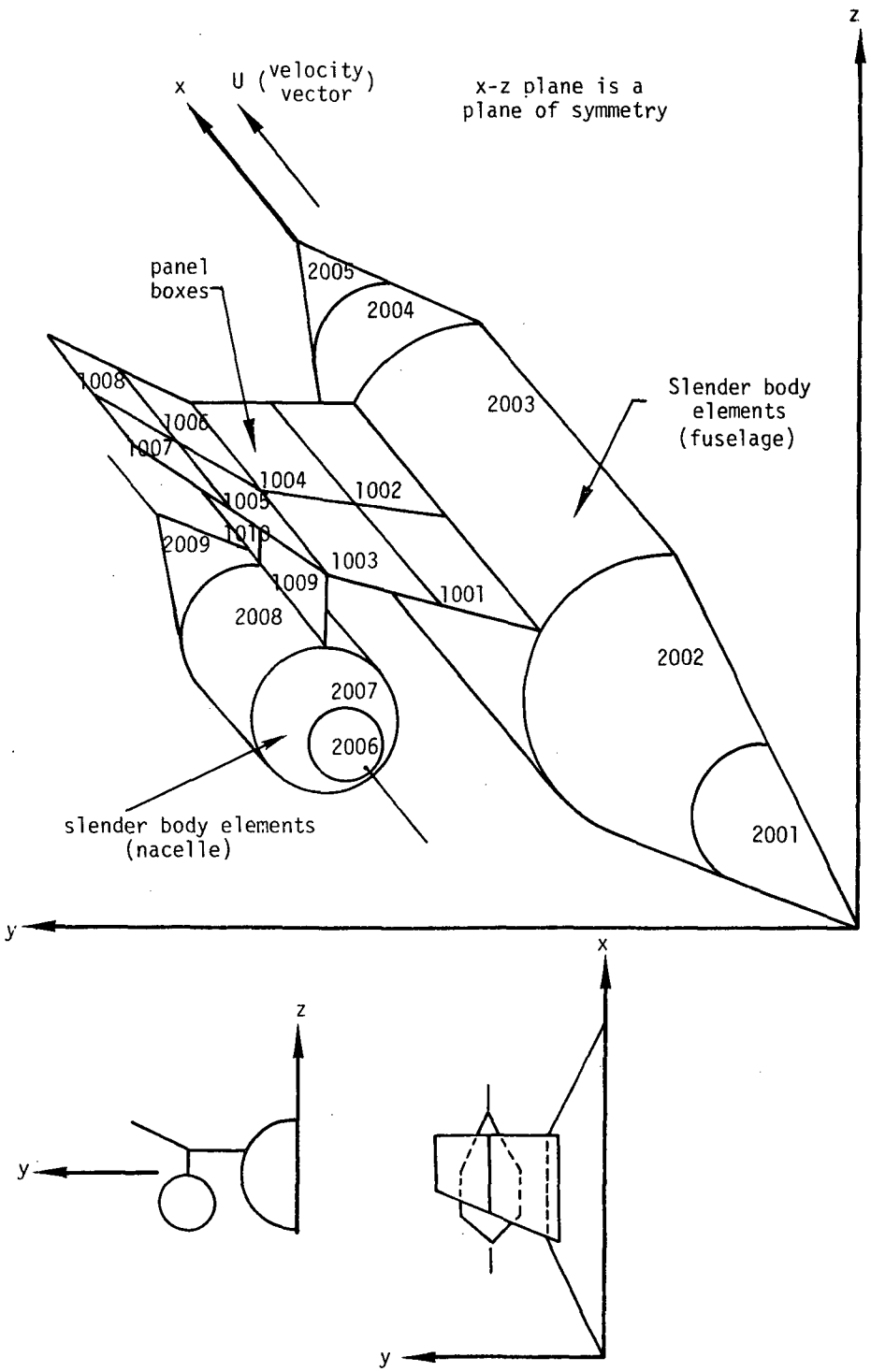
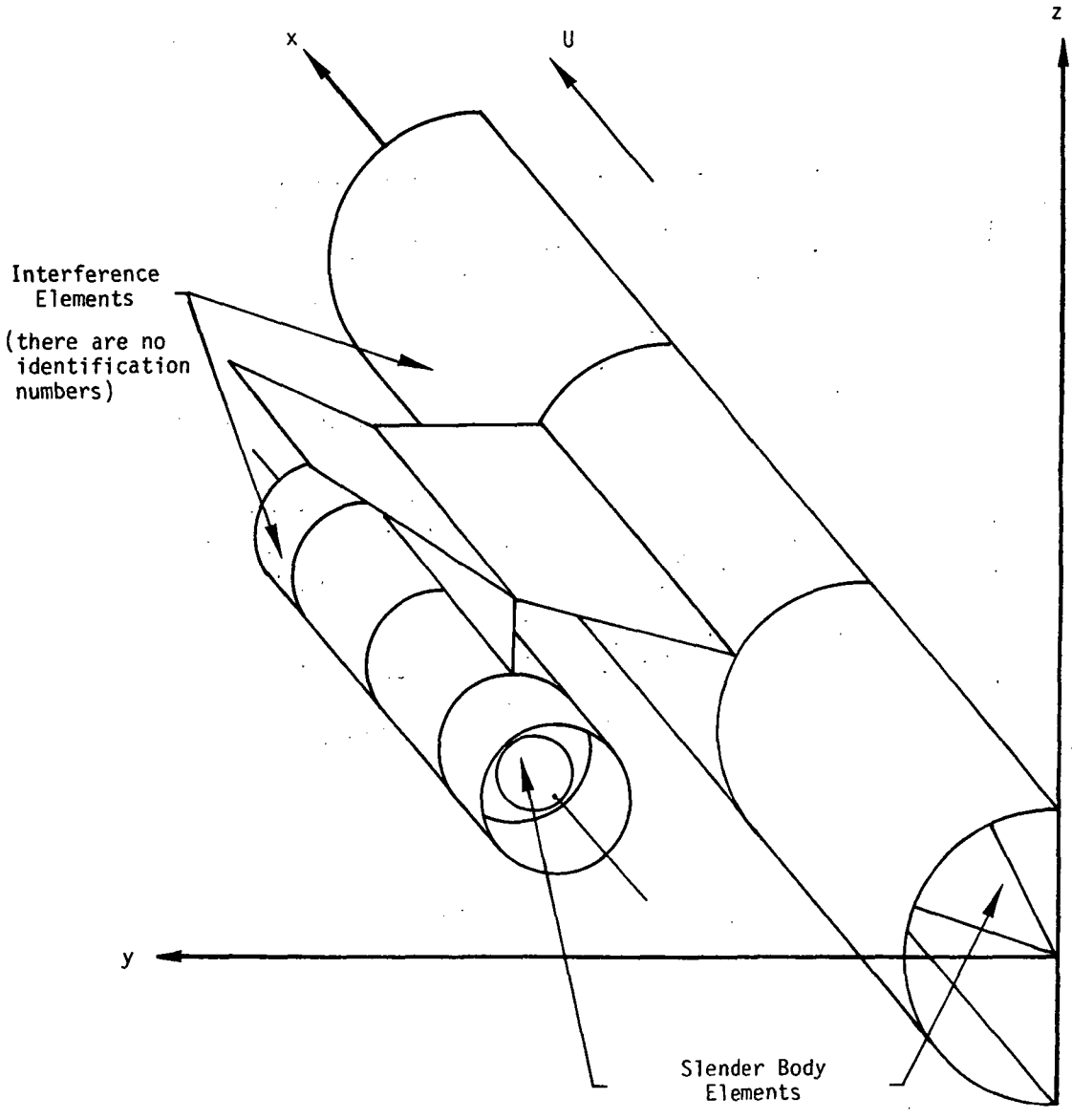


Figure 1. An aerodynamic Doublet-Lattice panel subdivided into boxes.



a) Showing boxes and slender body elements

Figure 2. N5KA example with three panels (ten boxes), two bodies (nine slender body elements), and seven interference elements.



b) Showing interference elements

Figure 2. N5KA example with three panels (ten boxes), two bodies (nine slender body elements), and seven interference elements.

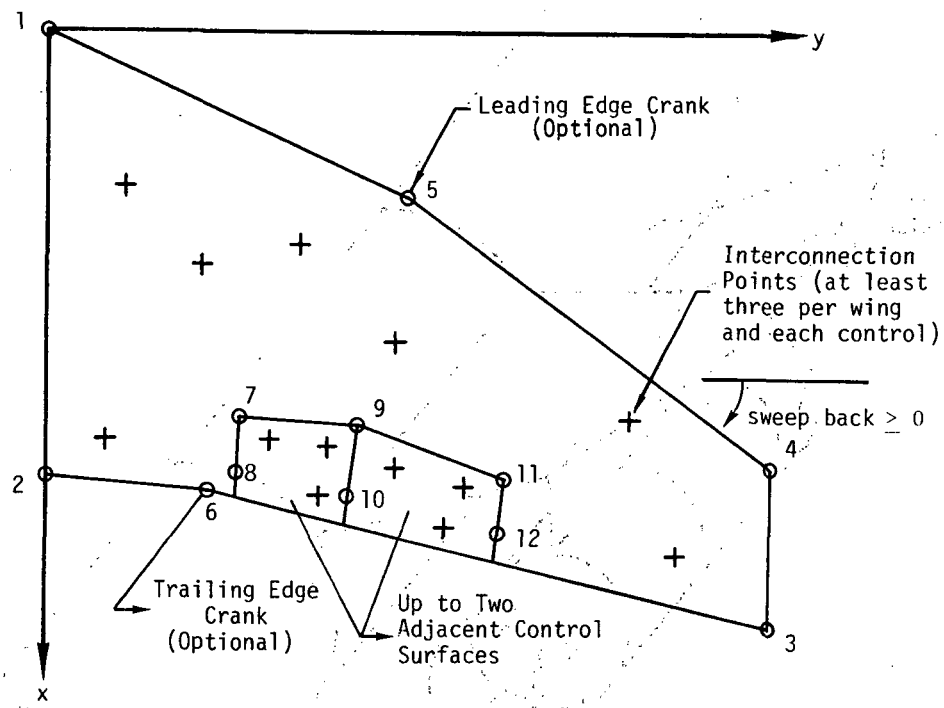
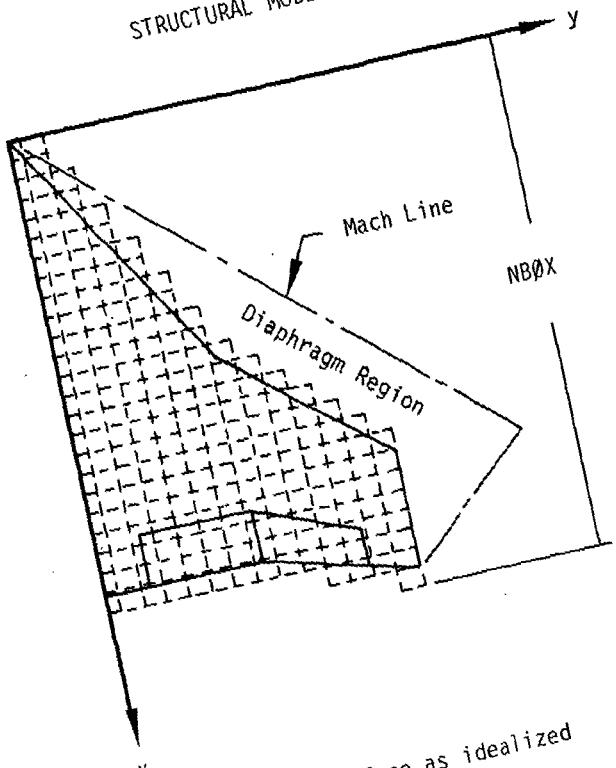


Figure 3. Mach box surface.



a) Surface as idealized

```
GRAPHIC DISPLAY OF REGIONS ON MAIN SEMISPAN        .043248
          BOX WIDTH      .052064          BOX LENGTH

                                          S    MAIN
                                          1    CNTRL1
                                          2    CNTRL2
                                          .    DIAPHRAGM
                                          ;    WAKE

MACH NUMBER   1.300
                SS
                SS.
                SSS.
                SSS..
                SSSS..
                SSSS...
                SSSSS...
                SSSSS....
                SSSSSS....
                SSSSSS.....
                SSSSSSS.....
                SSSSSSS......
                SSSSSSSS.....
                SSSSSSSS......
                SSSSSSSSS.....
                SSSSSSSSS......
                SSSSSSSSSS.....
                SSSSSSSSSS......
                SSSSSSSSSSS.....
                SSSSSSSSSSS......
                SSSSSSSSSSSS.....
                SSSSSSSSSSSS.....
                SS1111122SSSS....
                SS11111222SSS....
                SS111112222SS...
                SS1111122222SS..
                  22SS.
                    S
```

b) Surface as generated by program

Figure 4. Mach box surface showing Mach boxes and diaphragm.

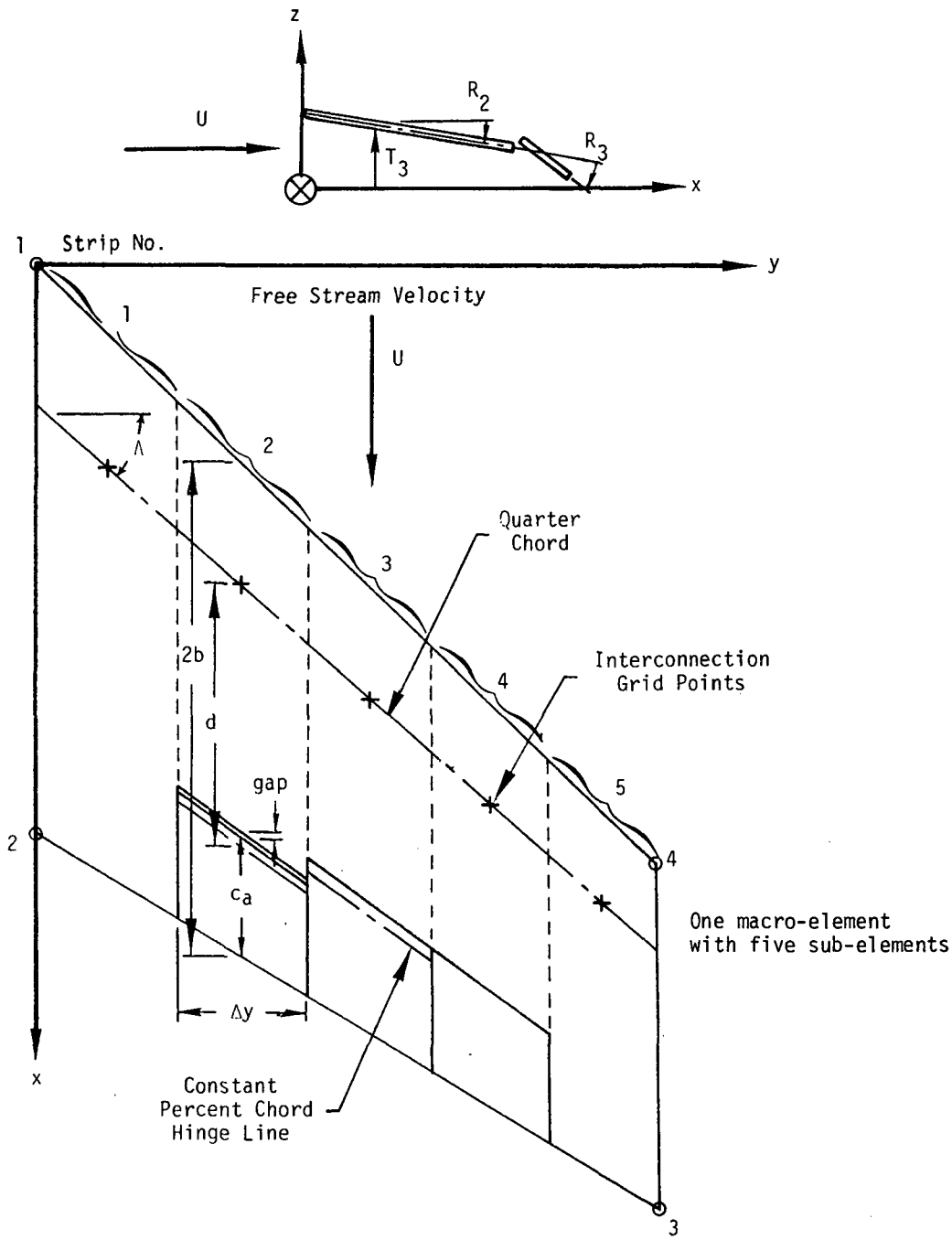


Figure 5. Strip theory example lifting surface.

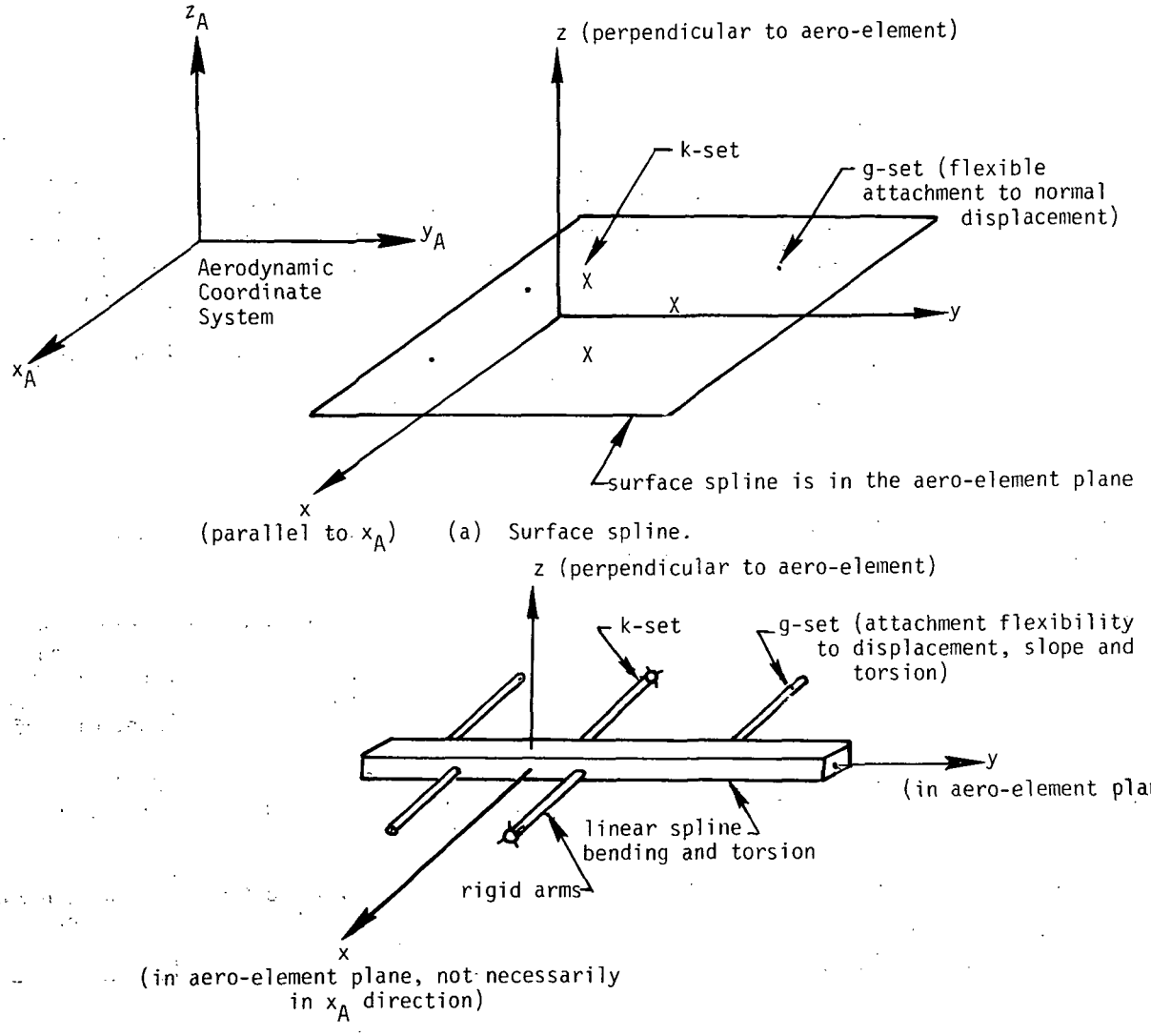


Figure 6. Splines and their coordinate systems.

Table 1. Aerodynamic elements.

Type	Doublet Lattice Panel	Lifting Body (Interference)	Mach Box Surface	Strip Theory	Piston Theory
Data Cards	CAERØ1 PAERØ1	CAERØ2 PAERØ2	CAERØ3 PAERØ3	CAERØ4 PAERØ4	CAERØ5 PAERØ5
Mach Number	Subsonic	Subsonic	Supersonic	All regimes	Hypersonic
Symmetry Options	2 planes y = 0 z = 0	2 planes y = 0 z = 0	1 plane required	None	None
Interaction	Panels and bodies in the same group		Boxes on one surface	None	None
Comments			One or two control surfaces	Control surface allowed. User may vary parameters.	A strip theory, coefficients from piston or Van Dyke theory Control surface
Interconnection to Structure	Box centers	Slender body element centers	User specified locations	Strip 1/4-chord	Strip 1/4-chord
Displacement Components Used at Connection Points	3,5	3,5 z-bodies 2,6 y-bodies	3	3,5 No control 3,5,6 Control	3,5 No control 3,5,6 Control

Table 2. Flutter analysis methods.

	"K"	"KE"	"PK"
Structural Matrices	K (complex) B (complex) M (complex)	K (complex) M (complex)	K (real) B (real) M (real)
Aerodynamic Matrices	M (complex)	M (complex)	K (real) B (real)
User Input Loops	ρ-density m-Mach number k-reduced frequency	ρ-density m-Mach number k-reduced frequency	ρ-density m-Mach number V-velocity
Output	V-g curve Complex modes Displacements Deformed plots	V-g curve	V-g curve Complex modes Displacements Deformed plots
Method	Compute roots for user input ρ, m, k.	Compute roots for user input ρ, m, k. Reorder output so a "curve" refers to a mode.	For each ρ, m, V, iterate on each root to find consistent results. (Details in the Theoretical Manual.)
Eigenvalue Method	Several methods available, selected by user via CMETHØD in case control.	Complex Upper* Hessenberg	Real Upper* Hessenberg

* No CMETHØD card is used.

REFERENCES

1. Giesing, J.P., T. P. Kálmán, and W. P. Rodden, "Subsonic Unsteady Aerodynamics for General Configurations," Part II; Volume I, Application of the Doublet-Lattice Method and the Method of Images to Lifting-Surface/Body Interference; AFFDL-TR-71-5; April 1972.

2. Giesing, J.P., T. P. Kálmán, and W. P. Rodden, "Subsonic Unsteady Aerodynamics for General Configurations," Part II; Volume II, Computer Program N5KA; AFFDL-TR-71-5, April 1972.

3. Yates, E. C. and R. M. Bennett, "Use of Aerodynamic Parameters from Nonlinear Theory in Modified-Strip-Analysis Flutter Calculations for Finite-Span Wings at Supersonic Speeds;" NASA TN D-1824; July 1963.

4. Bisplinghoff, R. L., H. Ashley, and R. L. Halfman, "Aeroelasticity," pp. 682, 691; Addison-Wesley; 1955.

2.2 EXECUTIVE CONTROL DECK

2.2.1 Control Selection

The format of the Executive control cards is free field. The name of the operation (e.g., CHKPNT) is separated from the operand by one or more blanks. The fields in the operand are separated by commas, and may be up to 8 integers or alphanumeric as indicated in the control card descriptions. The first character of an alphanumeric field must be alphabetic followed by up to 7 additional alphanumeric characters. Blank characters may be placed adjacent to separating commas if desired. The individual cards are described in Section 2.3.3 and examples follow in Section 2.2.2.

The following Executive Control cards are mandatory:

1. APP - selects a Rigid Format approach or a user provided Direct Matrix Abstraction Program (DMAP).
2. CEND - defines the end of the Executive Control deck.
3. ID - defines the beginning of the Executive Control deck.
4. TIME - defines the maximum time in minutes allotted to the execution of the NASTRAN program.

The following Executive Control cards are required under certain circumstances:

1. BEGIN$ - defines the beginning of user provided DMAP statements.
2. END$ - defines the end of user provided DMAP statements.
3. ENDALTER - defines the end of user provided changes to a Rigid Format.
4. RESTART - defines the beginning of a restart dictionary.
5. SØL - selects the solution number of a Rigid Format.
6. UMF - selects a data deck from a User Master File.
7. UMFEDIT - controls execution as a UMF editor.

The following Executive Control cards are optional:

1. ALTER - defines the Rigid Format statement(s) at which the user makes alterations.
2. CHKPNT - requests the execution to be checkpointed.
3. DIAG - requests diagnostic output to be provided or operations to be effected.
4. NUMF - requests a User Master File to be created.
5. $ - defines a non-executable comment.

2.2.2 Executive Control Deck Examples

1. Cold start, no checkpoint, rigid format, diagnostic output.

```
ID          MYNAME, BRIDGE23
APP         DISPLACEMENT
SØL         2,0
TIME        5
DIAG        1,2
CEND
```

2. Cold start, checkpoint, rigid format.

```
ID          PERSØNZZ, SPACECFT
CHKPNT      YES
APP         DISPLACEMENT
SØL         1,3
TIME        15
CEND
```

3. Restart, no checkpoint, rigid format. The restart dictionary indicated by the brace is automatically punched on previous run in which the CHKPNT option was selected by the user.

```
ID JØESHMØE, PRØJECTX
RESTART  PERSØNZZ, SPACECFT, 05/13/67, 18936,
     1, XVPS, FLAGS=0, REEL=1, FILE=6
     2, REENTER AT DMAP SEQUENCE NUMBER 7
     3, GPL, FLAGS=0, REEL=1, FILE=7
                    .
                    .
                    .
$ END ØF CHECKPØINT DICTIØNARY
APP         DISPLACEMENT
SØL         3,3
TIME        10
CEND
```

4. Cold start, no checkpoint, DMAP. User-written DMAP program is indicated by braces.

```
ID          IAM007, TRYIT
APP         DMAP
BEGIN $
{DMAP statements go here}
END $
TIME        8
CEND
```

5. Restart, checkpoint, altered rigid format, diagnostic output.

```
ID BEAM, FIXED
RESTART BEAM, FREE, 05/09/68, 77400,
     1, XVPS, FLAGS=0, REEL=1, FILE=6
     2, REENTER AT DMAP SEQUENCE NUMBER 7
     3, GPL, FLAGS=0, REEL=1, FILE=7
                    .
                    .
                    .
$ END ØF CHECKPØINT DICTIØNARY
```

```
CHKPNT      YES
DIAG        2,4
APP         DISPLACEMENT
SØL         3,3
TIME        15
ALTER       20
MATPRN      KGGX,,,,// $
TABPT       GPST,,,,// $
ENDALTER
CEND
```

2.3.3 Executive Control Card Descriptions

The format of the Executive Control cards is free-field. In presenting general formats for each card embodying all options, the following conventions are used:

1. Upper-case letters and parentheses must be punched as shown.
2. Lower-case letters indicate that a substitution must be made.
3. Braces { } indicate that a choice of contents is mandatory.
4. Brackets [] contain an option that may be omitted or included by the user.
5. Underlined options or values are the default values.
6. Physical card consists of information punched in columns 1 thru 72 of a card. Most Executive Control cards are limited to a single physical card.
7. Logical card may have more than 72 columns with the use of continuation cards. A continuation card is honored by ending the preceeding card with a comma.

Executive Control Card ALTER - DMAP Sequence Alteration Request

Description: Requests Direct Matrix Abstraction Program (DMAP) sequence for a Rigid Format to be changed by additions, deletions, or substitutions.

Format and Example(s):

ALTER {K1 [,K2]}

ALTER 22

ALTER 5,5

ALTER 38,45

Option	Meaning
K1 and K2	First and last DMAP instruction statement numbers of series to be deleted and replaced with any following DMAP instructions.
K1 only	Input following DMAP instructions after statement number K1.

Remarks:
1. Alter statement numbers must be in increasing order.
2. For a list of the Rigid Format DMAP sequences, see Section 3.

Executive Control Card APP - Rigid Format or DMAP Declaration

Description: Selects a Rigid Format approach or a user provided Direct Matrix Abstraction Program (DMAP).

Format and Example(s):

```
        ⎧DISPLACEMENT      ⎫
        ⎪DISPLACEMENT, SUBS⎪
APP     ⎨HEAT              ⎬
        ⎪AERØ              ⎪
        ⎪DMAP              ⎪
        ⎩DMAP, SUBS        ⎭
```

APP HEAT

APP DMAP

Option	Meaning
DISPLACEMENT	Indicates one of the Displacement Approach rigid formats.
DISPLACEMENT, SUBS	Indicates Automated Multi-stage Substructuring with one of the Displacement Approach rigid formats.
HEAT	Indicates one of the Heat Transfer Approach rigid formats.
AERØ	Indicates one of the Aeroelastic Approach rigid formats.
DMAP	Indicates Direct Matrix Abstraction Program (DMAP) Approach.
DMAP, SUBS	Indicates Direct Matrix Abstraction Program (DMAP) Approach which includes Automated Multi-stage Substructuring modules.

Remarks: 1. This card is mandatory.

Executive Control Card BEGIN - DMAP Sequence Initiation

Description: Defines the beginning of a Direct Matrix Abstraction Program (DMAP) sequence.

Format and Example(s):

BEGIN $

BEGIN ØPTIØNAL NAME ØF DMAP SEQUENCE $

Remarks:

1. This card is required at the beginning of a DMAP sequence. It must be the first card. The statement is included at the beginning of the DMAP sequence defining a Rigid Format. The user must provide the card as part of a user supplied DMAP sequence when using the DMAP approach.
2. This statement, like all DMAP statements, is terminated with the $ character delimiter.
3. This statement is a non-executable instruction for the DMAP compiler. (See Section 5.7 for an alternate Module XDMAP.)
4. For specific instructions related to DMAP useage, see Section 5.2.

Executive Control Card CEND - Executive Control Deck Terminator

Description: Defines the end of the Executive Control deck.

Format and Example(s):

CEND

Remarks: 1. This card is mandatory and must be last in the Executive Control Deck.

Executive Control Card CHKPNT - Checkpoint File Request

Description: Requests data blocks to be written to a checkpoint file for a later restart.

Format and Example(s):

CHKPNT $\begin{Bmatrix} \text{YES} \\ \underline{\text{NØ}} \end{Bmatrix}$

CHKPNT YES

Remarks:
1. This card is optional but when used, the checkpoint file must be made available by the user via operating system control cards.
2. The restart dictionary deck is automatically punched for use in a later restart execution.

Executive Control Card DIAG - Diagnostic Output and Operation Request

Description: Requests additional information to be printed out or requests executive operations to be performed.

Format and Example(s):

DIAG {n}

DIAG 14

DIAG 8,11,13

Option	Meaning
n	Integer to choose type of diagnostic (see Remarks)

Remarks: 1. One or more diagnostics may be chosen from the following table:

n	Diagnostic
1	Dump memory when fatal message is generated.
2	Print File Allocation Table (FIAT) following each call to the File Allocator.
3	Print status of the Data Pool Dictionary (PDP) following each call to the Data Pool Housekeeper.
4	Print the Operation Sequence Control Array (ØSCAR).
5	Print BEGIN time on-line for each functional module.
6	Print END time on-line for each functional module.
7	Print eigenvalue extraction diagnostics for real and complex determinant methods.
8	Print matrix and table data block trailers as they are generated.
9	Suppress echo of checkpoint dictionary.
10	Use alternate nonlinear loading in TRD. (Replace $\{N_{n+1}\}$ by $\frac{1}{3}\{N_{n+1} + N_n + N_{n-1}\}$)
11	Print all active row and column possibilities for decomposition algorithms.
12	Print eigenvalue extraction diagnostics for complex inverse power or FEER methods.
13	Print open core length.
14	Print the Rigid Format (NASTRAN SØURCE PRØGRAM CØMPILATIØN)
15	Trace GINØ ØPEN/CLØSE operations.
16	Trace real inverse power eigenvalue extraction operations or eigensolution diagnostics for FEER tridiagonalization.
17	Punch the DMAP sequence that is compiled.

18	Trace Heat Transfer iterations (APP HEAT) or print grid point ID conversions from SET2 card (APP AERØ).
19	Print data for MPYAD method selection.
20	Generate de-bug printout (For NASTRAN programmers who include CALL BUG in their subroutines).
21	Print GP4 set definition.
22	Print GP4 degree of freedom definition.
23	Print the DMAP alters generated during Automated Multi-stage Substructuring.
24	Punch the DMAP alters generated during Automated Multi-stage Substructuring.
25	
26	
27	Input File Processor (IFP) table dump.
28	Punch the link specification table (Deck XBSBD).
29	Process link specification table update deck.
30	Punch alters to the XSEMi decks (i set via DIAG 1-15).
31	Print link specification table and module properties list data.

2. Multiple options may be selected by using multiple integers separated by commas. Other options and other rules associated with the DIAG card, which primarily concern the programmer, can be found in Section 6.11.3 of the Programmer's Manual.

Executive Control Card END - DMAP Sequence Terminator

Description: Defines the end of a Direct Matrix Abstraction Program (DMAP) sequence.

Format and Example(s):

END$

Remarks:

1. This card is required at the end of a DMAP sequence. It must be the last card. The statement is included at the end of the DMAP sequence defining a Rigid Format. The user must provide the card as part of a user supplied DMAP sequence when using the DMAP approach.
2. This statement, like all DMAP statements, is terminated with the $ character delimiter.
3. For specific instructions related to DMAP useage, see Section 5.2.
4. The END $ statement cannot be altered into a Rigid Format at intermediate steps. To schedule an early termination, use either the EXIT $ statement or the JUMP, FINIS $ statement.

Executive Control Card ENDALTER - Rigid Format DMAP Alter Terminator

Description: Defines the end of a user supplied alter to a Rigid Format Direct Matrix Abstraction Program (DMAP) sequence.

Format and Example(s):

ENDALTER

Remarks:
1. This card is required when an alter to a Rigid Format DMAP sequence is supplied.
2. The card is required only once but must be the last card for all alters.
3. For specific instructions related to DMAP useage, see Section 5.2.

Executive Control Card ID - Job Identification

Description: Provides an alphanumeric identification of the job and establishes the beginning of the Executive Control deck.

Format and Example(s):

```
ID {A1,A2}
ID  A1234567,B7654321
```

Option	Meaning
A1	Any alphanumeric field chosen by the user for identification.
A2	Any alphanumeric field chosen by the user for identification.

Remarks:

1. This card is mandatory and must be first in the Executive Control deck.
2. The ID used during a checkpoint is automatically written to the checkpoint file and is placed on the restart card.
3. The first character of each field must be alphabetic and may be followed by up to seven alphanumeric characters.

Executive Control Card NUMF - New User Master File Declaration

Description: Defines a bulk data deck to be placed on a User Master File.

Format and Example(s):

NUMF {tid, pid}
NUMF 20012,6
NUMF 150,0

Option	Meaning
tid	User specified tape identification number assigned during the creation of a User's Master File.
pid	User specified problem identification number assigned during the creation of a User's Master File.

Remarks:
1. This card is required when the UMF Editor is in the write mode.
2. For specific instructions related to the UMF, see Section 2.5.

Executive Control Card RESTART - Restart Dictionary Initiator

Description: Defines the beginning of a restart dictionary deck when reading data blocks from the previously checkpointed file.

Format and Example(s):

RESTART {A1,A2,K1/K2/K3,K4,}
RESTART A1234567,B7654321,03/01/76,32400,

Option	Meaning
A1, A2	Fields taken from ID card of previously checkpointed problem.
K1/K2/K3	Month/Day/Year that Problem Tape was generated.
K4	Number of seconds after midnight at which XCSA begins execution.

Remarks:

1. The complete restart dictionary consists of this card followed by one card for each file checkpointed. The restart dictionary is automatically punched when operating in the checkpoint mode. All subsequent cards are continuations of this logical card. The entire dictionary deck is required for a restart.

2. Each continuation card begins with a sequence number. There are two types of continuation cards which are required and one that is not.

 Basic continuation card:

 NØ,DATABLØCK,FLAG=Y,REEL=Z,FILE=W

 where: NØ is the sequence number of the card. The entire dictionary must be in sequence by this number.

 DATABLØCK is the name of the data block referenced by this card.

 FLAG=Y defines the status of the data block where Y = 0 is the normal case and Y = 4 implies this data block is equivalenced to another data block. In this case (FLAG=4) the file number points to a previous data block which is the "actual" copy of the data.

 REEL=Z specifies the reel number as the Problem Tape can be a multi-reel tape. Z = 1 is the normal case.

 FILE=W specifies the GINØ (internal) file number of the data block on the Problem Tape. A zero value indicates the data block is purged. For example:

 1,GPL,FLAGS=0,REEL=1,FILE=7 says data block GPL occupies file 7 of reel 1.

 2,KGG,FLAGS=4,REEL=1,FILE=20 says KGG is equivalenced to the data block which occupies file 20. (Note that FLAGS=4 cards usually occur in at least pairs as the equivalenced operation is at least binary).

 3,USETD,FLAGS=0,REEL=1,FILE=0 implies USETD is purged.

Reentry point card:

NØ,REENTER AT DMAP SEQUENCE NUMBER N

where: NØ is the sequence number of the card.

N is the sequence number associated with the DMAP instruction at which the problem will restart. This value may be changed by adding a final such card (i.e., only the last such card is operative). This may be necessary when restarting from a Rigid Format to a DMAP sequence (to print a matrix for example).

End of dictionary card:

$ END ØF CHECKPØINT DICTIØNARY

This card is simply a comment card but is punched to signal the end of the dictionary for user convenience. The program does not need such a card. Terminations associated with non-NASTRAN failures (operator intervention, maximum time, etc.) will not have a card punched.

3. There are four types of restarts Unmodified Restart, Modified Restart, Rigid Format Switch and Pseudo Modified Restart. The function of the reentry point is different in each case. On an unmodified restart the program continues from the reentry point. On a modified restart modules which must be run to process the modified data but which are ahead of the reentry point are executed first. The program then continues from the reentry point. On a Rigid Format Switch (going from a Rigid Format to another) the reentry point is meaningless in that it was determined for another DMAP sequence. In this case the data blocks available are consulted to determine the proper sequence of modules to run. A Pseudo modified restart (defined by the existence of only changes to output producing data such as plotter requests) is treated like a modified restart. The type of restart is implied by the changes made in the NASTRAN Data Deck. No explicit request for a particular kind of restart is required. See Section 3.1 for additional information. In general, a restart cannot be accomplished from a checkpoint tape created on a previous NASTRAN level. This is primarily due to changes in the Rigid Formats which destroys the validity of the restart dictionary.

4. The previously checkpointed file must be made available by the user via operating system control cards.

Executive Control Card SØL - Solution Number Selection

Description: Selects the solution number which defines the Rigid Format.

Format and Example(s):

SØL $\left\{ \begin{matrix} K1 \\ A \end{matrix} \left[\begin{matrix} K2 \\ ,0 \end{matrix} \right] \right\}$

SØL 5

SØL 1,6

SØL 1,6,7,8,9

SØL STEADY STATE

Option	Meaning
K1	Solution number of Rigid Format (see Remarks below and Section 3).
K2	Subset numbers for solution K1, default value = 0.
A	Name of Rigid Format (see Remarks below).

Remarks:

1. When a Direct Matrix Abstraction Program (DMAP) is not used, the solution is mandatory. The subset associated with a solution is optional.

2. For Displacement Approach Rigid Formats, the integer value for K1 or the alphabetic characters for A must be selected from the following table:

K1	A
1	STATICS
2	INERTIA RELIEF
3	MØDES or NØRMAL MØDES or REAL EIGENVALUES
4	DIFFERENTIAL STIFFNESS
5	BUCKLING
6	PIECEWISE LINEAR
7	DIRECT CØMPLEX EIGENVALUES
8	DIRECT FREQUENCY RESPØNSE
9	DIRECT TRANSIENT RESPØNSE
10	MØDAL CØMPLEX EIGENVALUES
11	MØDAL FREQUENCY RESPØNSE
12	MØDAL TRANSIENT RESPØNSE
13	NØRMAL MØDES ANALYSIS WITH DIFFERENTIAL STIFFNESS
14	STATICS CYCLIC SYMMETRY
15	MØDES CYCLIC SYMMETRY

3. For Heat Approach Rigid Formats, the integer value for K1 or the alphabetic characters for A must be selected from the following table:

K1	A
1	STATICS
3	STEADY STATE
9	TRANSIENT

4. For Aero Approach Rigid Formats, the integer value for K1 or the alphabetic characters for A must be selected from the following table:

K1	A
10	MØDAL FLUTTER ANALYSIS
11	MØDAL AERØELASTIC RESPØNSE

5. Subsets cause a reduction in the number of statements in a Rigid Format. The use of a subset is optional. The integer value(s) may be selected from the following table:

K2	Subset Numbers
1	Delete loop control.
2	Delete mode acceleration method of data recovery (modal transient and modal frequency response).
3	Combine subsets 1 and 2.
4	Check all structural and aerodynamic data without execution of the aeroelastic problem.
5	Check only the aerodynamic data without execution of the aeroelastic problem.
6	Delete checkpoint instructions.
7	Delete structure plotting and X-Y plotting.
8	Delete Grid Point Weight Generator.
9	Delete fully stressed design (static analysis).

Multiple subsets may be selected by using multiple integers separated by commas.

Executive Control Card TIME - Maximum Execution Time Declaration

Description: Establishes the maximum time in minutes allotted to the execution of the NASTRAN program.

Format and Example(s):

TIME {n}

TIME 5

TIME 60

Option	Meaning
n	Integer number of minutes for execution.

Remarks:

1. This card is mandatory.
2. The time allotted via this card should be less than the time allotted the entire execution via operating system declaration.

Executive Control Card UMF - User Master File Selection

Description: Selects a bulk data deck stored on a User Master File.

Format and Example(s):

UMF {tid, pid}

UMF 20012,6

UMF 150,0

Option	Meaning
tid	Previously assigned tape identification number to access a Bulk Data Deck when using a User's Master File.
pid	Previously assigned problem identification number to access a Bulk Data Deck when using a User's Master File.

Remarks:
1. This card is required when the UMF Editor is in the read mode.
2. For specific instructions related to the UMF, see Section 2.5.

Executive Control Card UMFEDIT - User Master File Editor Selection

Description: Selects the UMF Editor and limits execution to the Preface only.

Format and Example(s):

UMFEDIT

Remarks:
1. This card is required to utilize the UMF Editor in a read or write mode.
2. Selection of the UMF Editor automatically limits execution to the Preface only, i.e., no computations may be performed when the Editor is used.
3. For specific instructions related to the UMF, see Section 2.5.

Executive Control Card $ - Comment Indicator

Description: Declares the character string is a non-executable comment.

Format and Example(s):

```
$ [any BCD string]
$ CØMMENTS MAY APPEAR IN ANY CØLUMNS
$ SPECIAL CHARACTERS MAY BE INCLUDED ( ) + . /
```

Remarks: 1. The $ character is a delimiter which allows comments to be written on the same physical card.

2.3 CASE CONTROL DECK

2.3.1 Data Selection

The Case Control cards that are used for selecting items from the Bulk Data Deck are listed below in functional groups. A detailed description of each card is given in Section 2.3.4. The first four characters of the mnemonic are sufficient if unique.

The following Case Control cards are associated with the selection of applied loads for both static and dynamic analysis:

1. DEFØRM - selects element deformation set.
2. DLØAD - selects dynamic loading condition.
3. DSCØEFFICIENT - selects loading factor for normal modes with differential stiffness.
4. LØAD - selects static structural loading condition or heat power and/or flux.
5. NØNLINEAR - selects nonlinear loading condition for transient response.
6. PLCØEFFICIENT - selects loading increments for piecewise linear analysis.

The following case control cards are used for the selection of constraints:

1. AXISYMMETRIC - selects boundary conditions for conical shell and axisymmetric solid elements or specifies the existence of fluid harmonics for a hydroelastic problem.
2. MPC - selects set of multipoint constraints for structural displacement or heat transfer boundary temperature relationships.
3. SPC - selects set of single-point constraints for structural displacements or heat transfer boundary temperatures.

The following case control cards are used for the selection of direct input matrices:

1. B2PP - selects direct input structural damping or thermal capacitance matrices.
2. K2PP - selects direct input structural stiffness or thermal conductance matrices.
3. M2PP - selects direct input mass matrices.
4. TFL - selects transfer functions.

The following case control cards specify the conditions for dynamic analyses:

1. CMETHØD - selects the conditions for complex eigenvalue extraction.
2. FREQUENCY - selects the frequencies to be used for frequency and random response calculations.
3. IC - selects the initial conditions for direct transient response.
4. METHØD - selects the conditions for real eigenvalue analysis.
5. RANDØM - selects the power spectral density functions to be used in random analysis.

6. SDAMPING - selects table to be used for determination of modal damping.
7. TSTEP - selects time steps to be used for integration in transient response problems.
8. FMETHØD - selects method to be used in aeroelastic flutter analysis.
9. GUST - selects aerodynamic gust loading in aeroelastic response analysis.

The following case control cards are associated with the use of thermal fields:

1. TEMPERATURE(LØAD) - selects thermal field to be used for determining equivalent static loads.
2. TEMPERATURE(MATERIAL) - selects thermal field to be used for determining structural material properties or an estimate of the temperature distribution for heat transfer iterations.
3. TEMPERATURE - selects thermal field for determining both equivalent static loads and material properties.

2.3.2 Output Selection

Printer output requests may be grouped in packets following ØUTPUT cards or the individual requests may be placed anywhere in the Case Control Deck ahead of any structure plotter or curve plotter requests. Plotter requests are described in Section 4. The Case Control cards that are used for output selection are listed below in functional groups. A detailed description of each card is given in Section 2.3.4.

The following cards are associated with output control, titling and bulk data echoes:

1. TITLE - defines a text to be printed on first line of each page of output.
2. SUBTITLE - defines a text to be printed on second line of each page of output.
3. LABEL - defines a text to be printed on third line of each page of output.
4. LINE - sets the number of data lines per printed page, default is 50 for 11-inch paper.
5. MAXLINES - sets the maximum number of output lines, default is 20,000.
6. ECHØ - selects echo options for Bulk Data Deck, default is a sorted bulk data echo.

The following cards are used in connection with some of the specific output requests for calculated quantities:

1. SET - defines lists of point numbers, elements numbers, or frequencies for use in output requests.
2. ØFREQUENCY - selects a set of frequencies to be used for output requests in frequency and aeroelastic response problems (default is all frequencies) or flutter velocities.
3. TSTEP - selects a set of time steps to be used for output requests in transient response problems.
4. ØTIME - selects a set of times to be used for output requests in transient analysis problems (default is all times).

The following cards are used to make output requests for the calculated response of components in the SØLUTIØN set (components in the direct or modal formulation of the general K system) for dynamics problems:

1. SACCELERATIØN - requests the acceleration of the independent components for a selected set of points or modal coordinates.

2. SDISPLACEMENT - requests the displacements of the independent components for a selected set of points or modal coordinates or the temperatures of the independent components for a selected set of points in heat transfer.

3. SVELØCITY - requests the velocities of the independent components for a selected set of points or modal coordinates or the change in temperature with respect to time of the independent components for a selected set of points in heat transfer.

4. NLLØAD - requests the nonlinear loads for a selected set of physical points (grid points and extra points introduced for dynamic analysis) in transient response problems.

The following cards are used to make output requests for stresses and forces, as well as the calculated response of degrees of freedom used in the model:

1. FØRCE or ELFØRCE - requests the forces in a set of structural elements or the temperature gradients and fluxes in a set of structural or heat elements in heat transfer.

2. STRESS or ELSTRESS - requests the stresses in a set of structural elements or the velocity components in a fluid element in acoustic cavity analysis.

3. SPCFØRCES - requests the single-point forces of constraint at a set of points or the thermal power transmitted to a selected set of points in heat transfer.

4. ØLØAD - selects a set of applied loads for output.

5. ACCELERATIØN - requests the accelerations for a selected set of PHYSICAL points (grid, scalar and fluid points plus extra points introduced for dynamic analysis).

6. DISPLACEMENT - requests the displacements for a selected set of PHYSICAL points or the temperatures for a selected set of PHYSICAL points in heat transfer or the pressures for a selected set of PHYSICAL points in hydroelasticity.

7. VELØCITY - requests the velocities for a selected set of PHYSICAL points or the change in temperatures with respect to time for a selected set of PHYSICAL points in heat transfer.

8. HARMØNICS - controls the number of harmonics that will be output for requests associated with the conical shell, axisymmetric solids and hydroelastic problems.

9. ESE - requests structural element strain energies in Rigid Format 1.

10. GPFØRCE - requests grid point force balance due to element forces, forces of single point constraint, and applied loads in Rigid Format 1.

11. THERMAL - requests temperatures for a set of PHYSICAL points in heat transfer.

12. PRESSURE - requests pressures for a set of PHYSICAL points in hydroelasticity.

13. VECTØR - requests displacements for a selected set of PHYSICAL points.

14. MPCFØRCES - requests multipoint forces of constraint at a set of points in Rigid Formats 1, 2, 3, 14, and 15.

15. NCHECK - requests significant digits to indicate numerical accuracy of element stress and force computations.

16. AERØFØRCE - requests frequency dependent aerodynamic laods on interconnection points in aeroelastic response analysis.

17. STRAIN - requests the strains/curvatures in a set of structural elements (applicable to TRIA1, TRIA2, QUAD1, and QUAD2 only).

2.3.3 Subcase Definition

In general, a separate subcase is defined for each loading condition. In statics problems separate subcases are also defined for each set of constraints. In complex eigenvalue analysis and frequency response separate subcases are defined for each unique set of direct input matrices. Subcases may be used in connection with output requests, such as in requesting different output for each mode in a real eigenvalue problem.

The Case Control Deck is structured so that a minimum amount of repetition is required. Only one level of subcase definition is necessary. All items placed above the subcase level (ahead of the first subcase) will be used for all following subcases, unless overridden within the individual subcase.

In statics problems, subcases may be combined through the use of the SUBCØM feature. Individual loads may be defined in separate subcases and then combined by the SUBCØM. If the loads are mechanical, the responses are combined as shown in example 2, which follows. If a thermal load is involved, the responses due to mechanical and thermal loads may be recovered as shown in example 1. By redefining the thermal load(s) at the SUBCØM level, stresses and forces may be recovered.

CASE CONTROL DECK

In static problems, provision has been made for the combination of the results of several subcases. This is convenient for studying various combinations of individual loading conditions and for the superposition of solutions for symmetrical and antisymmetrical boundaries.

Typical examples of subcase definition are given following a brief description of the cards used in subcase definitions.

The following case control cards are associated with subcase definition:

1. SUBCASE - defines the beginning of a subcase that is terminated by the next subcase delimiters encountered.

2. SUBCØM - defines a combination of two or more immediately preceeding subcases in statics problems. Output requests above the subcase level are used.

3. SUBSEQ - must appear in a subcase defined by SUBCØM to give the coefficients for making the linear combination of the preceding subcases.

4. SYM - defines a subcase in statics problems for which only output requests within the subcase will be honored. Primarily for use with symmetry problems where the individual parts of the solution may not be of interest.

5. SYMCØM - defines a combination of two or more immediately preceeding SYM subcases in static problems. Output requests above the subcase level are used.

6. SYMSEQ - may appear in a subcase defined by SYMCØM to give the coefficient for making the linear combination of the preceeding SYM subcases. A default value of 1.0 is used if no SYMSEQ card appears.

7. REPCASE - defines a subcase in statics problems that is used to make additional output requests for the previous real subcase. This card is required because multiple output requests for the same item are not permitted in the same subcase. Output requests above the subcase level are still used.

8. MØDES - controls the output for a given subcase as specified by the number of modes, otherwise all modes will be used.

The following examples of Case Control Decks indicate typical ways of defining subcases:

1. Static analysis with multiple loads.

```
ØUTPUT
    DISPLACEMENT = ALL
MPC = 3
    SUBCASE 1
        SPC = 2
        TEMPERATURE(LØAD) = 101
        LØAD = 11
    SUBCASE 2
        SPC = 2
        DEFØRM = 52
        LØAD = 12
    SUBCASE 3
        SPC = 4
        LØAD = 12
    SUBCASE 4
        MPC = 4
        SPC = 4
```

Case Control Data Card AERØF - Aerodynamic Force Output Request

Description: Requests the aerodynamic loads on the interconnection points.

Format and Example(s):

AERØF = n

AERØF = ALL

AERØF = 5

Option	Meaning
n	Set identification of a previously appearing SET card. Only aerodynamic forces on points referenced will be output.
ALL	Aerodynamic forces on all points will be output.

Remarks:
1. Only frequency-dependent forces may be requested (frequency response or random analysis).
2. The point identification numbers are the box or body element IDs.
3. The dimensions of the output are force (or moment) per unit dynamic pressure.

Case Control Data Card AXISYMMETRIC - Boundary Conditions or Hydroelastic Harmonics.

Description: Selects boundary conditions for problems containing CCØNEAX, CTRAPAX or CTRIAAX elements or specifies the existence of fluid harmonics for hydroelastic problems.

Format and Example(s):

AXISYMMETRIC = $\left\{\begin{matrix}\text{SINE} \\ \text{CØSINE} \\ \text{FLUID}\end{matrix}\right\}$

AXISYMMETRIC = CØSINE

Option	Meaning
SINE	Sine boundary conditions will be used.
CØSINE	Cosine boundary conditions will be used.
FLUID	Existence of fluid harmonics.

Remarks:
1. This card is required for problems containing the elements named above.
2. If this card is used for hydroelastic problems, at least one harmonic must be specified on the AXIF card.
3. See Section 1.3.6 of User's Manual for a discussion of the conical shell problem.
4. See Section 1.3.7 of User's Manual for a discussion of the axisymmetric solid problem.
5. See Section 1.7.1 of User's Manual for a discussion of the hydroelastic formulation.
6. The sine boundary condition will constrain components 1, 3 and 5 at every ring for the zero harmonic.
7. The cosine boundary condition will constrain components 2, 4 and 6 at every ring for the zero harmonic.
8. SPC and MPC case control cards may also be used to effect additional constraints.

Case Control Data Card BEGIN BULK - End of Case Control Deck

Description: Terminates the end of the Case Control Deck directives and controls. Cards appearing after this card are assumed to be Bulk Data Deck cards.

Format and Example(s):

ENDDATA

Remarks: 1. The ENDDATA card must begin in column 1 or 2.

CASE CONTROL DECK

Case Control Data Card B2PP - Direct Input Damping Matrix Selection.

Description: Selects a direct input damping matrix.

Format and Example(s):

B2PP = name
B2PP = BDMIG
B2PP = B2PP

Option	Meaning
name	BCD name of $[B^2_{pp}]$ matrix that is input on the DMIG or DMIAX bulk data card.

Remarks: 1. B2PP is used only in dynamics problems.

2. DMIG and DMIAX matrices will not be used unless selected.

Case Control Data Card ELFØRCE - Element Force Output Request.

Description: Requests form and type of element force output.

Format and Example(s):

$$\text{ELFØRCE} \quad \left[\left(\begin{matrix}\text{SØRT1} \\ \text{SØRT2}\end{matrix}, \begin{matrix}\text{PRINT} \\ \text{PUNCH}\end{matrix}, \begin{matrix}\text{REAL} \\ \text{IMAG} \\ \text{PHASE}\end{matrix}\right)\right] = \left\{\begin{matrix}\text{ALL} \\ \text{n} \\ \text{NØNE}\end{matrix}\right\}$$

ELFØRCE = ALL

ELFØRCE(REAL, PUNCH, PRINT) = 17

ELFØRCE = 25

Option	Meaning
SØRT1	Output will be presented as a tabular listing of elements for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each element type. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0° \leq$ phase $< 360.0°$) on Complex Eigenvalue or Frequency Response problems.
ALL	Forces for all elements will be output.
NØNE	Forces for no elements will be output.
n	Set identification of a previously appearing SET card. Only forces of elements whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:
1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In Static Analysis or Frequency Response problems, any request for SØRT2 output causes all output to be SØRT2.
4. FØRCE is an alternate form and is entirely equivalent to ELFØRCE.
5. ELFØRCE = NØNE allows overriding an overall request.
6. In heat transfer analysis, ELFØRCE output consists of heat flow through and out of the elements.

Case Control Data Card ELSTRESS - Element Stress Output Request.

Description: Requests form and type of element stress output.

Format and Example(s):

$$\text{ELSTRESS} \quad \left[\left(\begin{matrix}\text{SØRT1}\\ \text{SØRT2}\end{matrix}, \begin{matrix}\text{PRINT}\\ \text{PUNCH}\end{matrix}, \begin{matrix}\text{REAL}\\ \text{IMAG}\\ \text{PHASE}\end{matrix}\right)\right] = \left\{\begin{matrix}\text{ALL}\\ \text{n}\\ \text{NØNE}\end{matrix}\right\}$$

ELSTRESS = 5

ELSTRESS = ALL

ELSTRESS(SØRT1, PRINT, PUNCH, PHASE) = 15

Option	Meaning
SØRT1	Output will be presented as a tabular listing of elements for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each element type. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary printout on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0° \leq$ phase $< 360.0°$) on Complex Eigenvalue or Frequency Response problems.
ALL	Stresses for all elements will be output.
n	Set identification of a previously appearing SET card (Integer > 0). Only stresses for elements whose identification numbers appear on this SET card will be output.
NØNE	Stress for no elements will be output.

Remarks:

1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In Static Analysis or Frequency Response problems, any request for SØRT2 output causes all output to be SØRT2.
4. STRESS is an alternate form and is entirely equivalent to ELSTRESS.
5. ELSTRESS = NØNE allows overriding an overall output request.
6. If element stresses in material coordinate system are desired (only for TRIA1, TRIA2, QUAD1 and QUAD2 elements and only in Rigid Format 1), the parameter STRESS (see the description of the PARAM bulk data card in Section 2.4.2) should be set to be a positive integer. If, in addition to element stresses in material coordinate system, stresses at the connected grid points are also desired, the parameter STRESS should be set to 0.

Case Control Data Card GPFØRCE - Grid Point Force Balance Output Request

Description: Requests grid point force balance output from applied loads, single-point constraints, and element contraints.

Format and Example (s):

GPFØRCE $\left[\left(\frac{\text{PRINT}}{\text{PUNCH}}\right)\right] = \left\{\begin{matrix}\text{ALL}\\ \text{n}\\ \text{NØNE}\end{matrix}\right\}$

Option	Meaning
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
ALL	Force balance will be output for all elements connected to grid points or scalar points.
NØNE	Force balance for no grid points will be output.
n	Set identification of previously appearing SET card (Integer >0). Only force balance for points whose identification numbers appear on this SET card will be output.

Remarks:

1. Grid point force balance is output from Statics Analysis (Rigid Format 1) only.
2. The output will be in SØRT 1 format.
3. Both PRINT and PUNCH may be requested.
4. GPFØRCE = NØNE allows overriding an overall output request.

Case Control Data Card GUST - Aerodynamic Gust Load Request

Description: Selects the gust field in an Aeroelastic Response problem.

Format and Example(s):

GUST = n

GUST = 73

Option	Meaning
n	Set identification of a GUST bulk data card (Integer > 0).

Remarks:
1. The above gust will not be used by NASTRAN unless selected in Case Control.
2. The choice of transient or frequency response gust depends upon the type of TLØAD or RLØAD referenced on the selected GUST card.

Case Control Data Card LINE - Data Lines Per Page.

Description: Defines the number of data lines per printed page.

Format and Example(s):

LINE = $\left\{\frac{50}{n}\right\}$ IBM or CDC

LINE = $\left\{\frac{45}{n}\right\}$ UNIVAC

LINE = 35

Option	Meaning
n	Number of data lines per page (Integer > 0).

Remarks:
1. If no LINE card appears, the appropriate default is used.
2. For 11 inch paper, 50 is the recommended number; for 8-1/2 inch paper, 35 is the recommended number.

Case Control Data Card LØAD - External Static Load Set Selection.

Description: Selects the external static load set to be applied to the structural model.

Format and Example(s):

LØAD = n

LØAD = 15

Option	Meaning
n	Set identification of at least one external load card and hence must appear on at least one FØRCE, FØRCE1, FØRCE2, MØMENT, MØMENT1, MØMENT2, GRAV, PLØAD, PLØAD2, PLØAD3, RFØRCE, PRESAX, FØRCEAX, MØMAX, SLØAD, or LØAD card (Integer > 0).

Remarks:

1. The above static load cards will not be used by NASTRAN unless selected in Case Control.
2. A GRAV card cannot have the same set identification number as any of the other loading card types. If it is desired to apply a gravity load along with other static loads, a LØAD bulk data card must be used.
3. LØAD is only applicable in statics, inertia relief, differential stiffness, buckling, and piecewise linear problems.
4. The total load applied will be the sum of external (LØAD), thermal (TEMP(LØAD)), element deformation (DEFØRM) and constrained displacement (SPC) Loads.
5. Static, thermal and element deformation loads must have unique set identification numbers.
6. Each of the rigid formats that accept a static load card expect it to appear in the Case Control Deck in a certain place with respect to subcase definitions. See Section 3 for specific instructions.

Case Control Data Card MPC - Multipoint Constraint Set Selection.

Description: Selects the multipoint constraint set to be applied to the structural model.

Format and Example(s):

MPC = n

MPC = 17

Option	Meaning
n	Set identification of a Multipoint-Constraint Set and hence must appear on at least one MPC, MPCADD, MPCAX, or MPCS card. (Integer > 0).

Remarks: MPC, MPCADD, MPCAX, or MPCS cards will not be used by NASTRAN unless selected in Case Control.

Case Control Data Card MPCFØRCES - Multipoint Forces of Constraint Output Request

Description: Requests multipoint force of constraint vector output.

Format and Example(s):

$$\text{MPCFØRCES} \left[\left(\text{SØRT1}, \frac{\text{PRINT}}{\text{PUNCH}} \right) \right] = \left\{ \begin{matrix} \text{ALL} \\ \text{n} \\ \text{NØNE} \end{matrix} \right\}$$

MPCFØRCE = 10

MPCFØRCE(PRINT,PUNCH) = ALL

MPCFØRCE = NØNE

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each subcase or frequency, depending on the rigid format. SØRT2 is not available.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
ALL	Multipoint forces of constraint for all points will be output (only nonzero entries).
NØNE	Multipoint forces of constraint for no points will be output.
n	Set identification of previously appearing SET card. Only multipoint constraint forces for points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:
1. Both PRINT and PUNCH may be requested.
2. MPCFØRCE = NØNE allows overriding an overall output request.
3. Only valid for statics and real eigenvalue analyses.
4. A request for MPCFØRCE is not allowed for axisymemtric elements.

Case Control Data Card NCHECK - Stress and Element Forces Numerical Accuracy Check

Description: Requests stress and element force numerical accuracy check.

Format and Example(s):

NCHECK [= n]
NCHECK
NCHECK = 6

Option	Meaning
n	A printout of the number of significant digits accuracy is issued for each element having an entry with less than n significant digits in the stress or force calculation.

Remarks:

1. All the elements requested on the STRESS and/or FØRCE card (or their equivalent ELSTRESS and/or ELFØRCE card) are checked.
2. The default for n is five (5) when n is not specified.
3. These checks measure the quality of the computations to obtain element stresses and element forces. They do not measure the quality of the model being analyzed.
4. See Theoretical Manual Section 3.7.2 for a description of the accuracy check.
5. The printout identifies the element types, identification number and the subcase. The entries checked are as follows.

Element Type	Entries
RØD,CØNRØD,TUBE	$F_A, T, \sigma_A, \sigma_T$
BAR	$F_A, T, M_{1a}, M_{1b}, M_{2a}, M_{2b}, V_1, V_2, \sigma_a$
TRMEM,QDMEM,QDMEM1	$\sigma_x, \sigma_y, \tau_{xy}$
TRPLT,QDPLT,TRIA1,TRIA2,QUAD1,QUAD2,TRBSC	$\sigma_{x1}, \sigma_{y1}, \sigma_{xy1}, \sigma_{x2}, \sigma_{y2}, \tau_{xy2}, M_x, M_y, M_{xy}, V_x, V_y$
HEXA1,HEXA2,WEDGE,TETRA	$\sigma_x, \sigma_y, \sigma_z, \tau_{yz}, \tau_{xz}, \tau_{xy}$
SHEAR	$\sigma_{MAX}, \sigma_{AVE}$, corner forces, kick forces, and shears.
TWIST	$\sigma_{MAX}, \sigma_{AVE}, M_{1-3}, M_{2-4}$
QDMEM2	$\sigma_x, \sigma_y, \tau_{xy}$, corner forces, kick forces, and shears.
IHEX1, IHEX2, IHEX3	σ_{NORMAL}, σ_{SHEAR}, and $\sigma_{PRINCIPAL}$ for each direction, grid point, and centroid.

Case Control Data Card NLLØAD - Nonlinear Load Output Request.

Description: Requests form and type of nonlinear load output for Transient problems.

Format and Example(s):

$$\text{NLLØAD } [(\frac{\text{PRINT}}{\text{PUNCH}})] = \begin{Bmatrix} \text{ALL} \\ n \\ \text{NØNE} \end{Bmatrix}$$

NLLØAD = ALL

Option	Meaning
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
ALL	Nonlinear loads for all solution points will be output.
NØNE	Nonlinear loads will not be output.
n	Set identification of previously appearing SET card. (Integer > 0). Only nonlinear loads for points whose identification numbers appear on this SET card will be output.

Remarks:
1. Both PRINT and PUNCH may be used.
2. Nonlinear loads are output only in the solution (D or H) set.
3. The output format will be SØRT2.
4. An output request for ALL in Transient response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
5. THERMAL = NØNE allows overriding an overall output request.

Case Control Data Card STRAIN - Element Strain/Curvature Output Request

Description: Requests element strain/curvature output.

Format and Example(s):

STRAIN $\left[\left(\frac{\text{PRINT}}{\text{PUNCH}}\right)\right] = \left\{\begin{matrix}\text{ALL}\\ \text{n}\\ \text{NØNE}\end{matrix}\right\}$

STRAIN (PUNCH) = 5

STRAIN (PRINT,PUNCH) = ALL

Option	Meaning
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output mdeia.
ALL	Strains/curvatures for all elements will be output. See Remark 5.
NØNE	Strains/curvatures for no elements will be output.
n	Set identification of previously appearing SET card (Integer > 0). Only strains/curvatures for elements whose identification numbers appear on this SET card will be output. See Remark 5.

Remarks:
1. Element strains/curvatures are output from Static Analysis (Rigid Format 1) only.
2. The output will be in SØRT1 format.
3. Both PRINT and PUNCH may be requested.
4. STRAIN = NØNE allows overriding an overall output request.
5. Strains/curvatures are computed only for TRIA1, TRIA2, QUAD1, and QUAD2 elements.
6. If element strains/curvatures in material coordinate system are desired, the parameter STRAIN (see the description of the PARAM bulk data card in Section 2.4.2) should be set to be a positive integer. If, in addition to element strains/curvatures in material coordinate system, strains/curvatures at the connected grid points are also desired, the parameter STRAIN should be set to 0.

Case Control Data Card STRESS - Element Stress Output Request.

Description: Requests form and type of element stress output.

Format and Example(s):

$$\text{STRESS} \quad \left[\left(\begin{matrix}\text{SØRT1} \\ \text{SØRT2}\end{matrix}, \begin{matrix}\text{PRINT} \\ \text{PUNCH}\end{matrix}, \begin{matrix}\text{REAL} \\ \text{IMAG} \\ \text{PHASE}\end{matrix}\right)\right] = \left\{\begin{matrix}\text{ALL} \\ \text{n} \\ \text{NØNE}\end{matrix}\right\}$$

STRESS = 5

STRESS = ALL

STRESS(SØRT1, PRINT, PUNCH, PHASE) = 15

Option	Meaning
SØRT1	Output will be presented as a tabular listing of elements for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each element type. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary printout on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0° \leq$ phase $< 360.0°$) on Complex Eigenvalue or Frequency Response problems.
ALL	Stresses for all elements will be output.
n	Set identification of a previously appearing SET card (Integer > 0). Only stresses for elements whose identification numbers appear on this SET card will be output.
NØNE	Stresses for no points will be output.

Remarks:

1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In Static Analysis or Frequency Response problems, any request for SØRT2 output causes all output to be SØRT2.
4. ELSTRESS is an alternate form and is entirely equivalent to STRESS.
5. STRESS = NØNE allows overriding an overall output request.
6. If element stresses in material coordinate system are desired (only for TRIA1, TRIA2, QUAD1 and QUAD2 elements and only in Rigid Format 1), the parameter STRESS (see the description of the PARAM bulk data card in Section 2.4.2) should be set to be a positive integer. If, in addition to element stresses in material coordinate system, stresses at the connected grid points are also desired, the parameter STRESS should be set to 0.

Case Control Data Card SUBCASE - Subcase Delimiter.

Description: Delimits and identifies a subcase.

Format and Example(s):

SUBCASE n
SUBCASE 101

Option	Meaning
n	Subcase identification number (Integer > 0).

Remarks: 1. The subcase identification number, n, must be strictly increasing (i.e., greater than all previous subcase identification numbers).

2. Plot requests and RANDØM requests refer to n.

Input Data Card CAERØ2 Aerodynamic Body Connection

Description: Defines an aerodynamic body for Doublet-Lattice aerodynamics.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CAERØ2	EID	PID	CP	NSB	NINT	LSB	LINT	IGID	ABC
CAERØ2	1500	2	100		4	99		1	abc
+BC	X1	Y1	Z1	X12					
+bc	-1.0	100.	-30.	175.					

Field	Contents
EID	Element identification number (Integer > 0).
PID	Property identification number (Integer > 0).
CP	Coordinate system for locating point 1 (Integer ≥ 0).
NSB	Number of slender body elements; if a positive number is given, NSB equal divisions are assumed; if zero or blank, see field 7 for a list of divisions (Integer ≥ 0).
NINT	Number of interference elements; if a positive number is given, NINT equal divisions are assumed; if zero or blank, see field 8 for a list of divisions (Integer ≥ 0).
LSB	ID of an AEFACT data card for slender body division points; used only if field 5 is zero or blank (Integer ≥ 0).
LINT	ID of an AEFACT data card containing a list of division points for interference elements used only if field 6 is zero or blank (Integer ≥ 0).
IGID	Interference group identification (aerodynamic elements with different IGID's are uncoupled) (Integer > 0).
X1,Y1,Z1	Location of point 1 in coordinate system CP (Real).
X12	Length of body in the x-direction of the aerodynamic coordinate system (Real > 0).

Remarks:

1. Point 1 is the leading point of the body.
2. All CAERØ1 (panels) and CAERØ2 (bodies) in the same group (IGID) will have aerodynamic interaction.
3. Interference elements are optional, but if used at least one element is required for each aerodynamic body specified by this card.
4. Element identification numbers on the aerodynamic bodies must have the following sequence:

 (a) CAERØ1 Panels first (lowest number)

 (b) Z-bodies (see PAERØ2 ØRIENTation flag)

 (c) ZY-bodies

 (d) Y-bodies (highest number).

 and they must be unique with respect to all structural grid ID's.

5. The total number of interference bodies associated with a panel is limited to six.

6. At least two slender body elements are required for every aerodynamic body specified by this card.

Input Data Card CAERØ3 Aerodynamic Mach Box Surface Connection

Description: Defines the aerodynamic edges of a Mach Box lifting surface. If no cranks are present, this card defines the aerodynamic Mach Box lifting surface.

Format and Example:

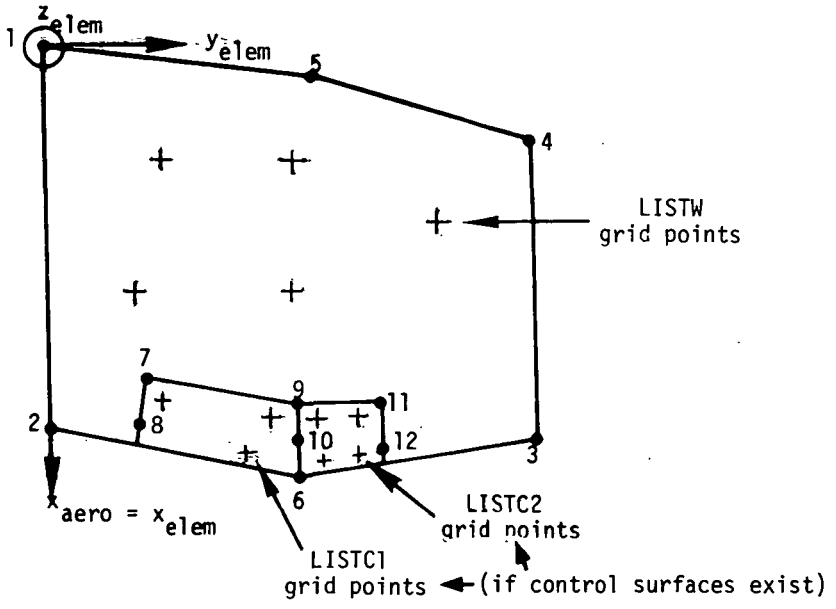
1	2	3	4	5	6	7	8	9	10
CAERØ3	EID	PID	CP	LISTW	LISTC1	LISTC2			ABC
CAERØ3	2000	2001	0	22	33				abc
+BC	X1	Y1	Z1	X12	X4	Y4	Z4	X43	
+bc	1.0	0.0	0.0	100.	17.	130.	0.	100.	

Field	Contents
EID	Element identification number (Integer > 0).
PID	Property identification number (Integer > 0).
CP	Coordinate system for locating points 1 and 4 (Integer ≥ 0).
LISTW	The ID of an AEFACT data card which lists (x,y) pairs of structural interpolation grid points of the wing (Integer > 0).
LISTC1 LISTC2	The ID of AEFACT data cards which list (x,y) pairs for controls (if they exist) (Integers ≥ 0).
X1,Y1,Z1 X4,Y4,Z4	Location of points 1 and 4 in coordinate system CP (Real).
X12,X43	Edge chord lengths (in aerodynamic coordinate system) Real ≥ 0, X12 ≠ 0.).

Remarks:

1. The x,y pairs of LISTW, LISTC1, and LISTC2 (AEFACT) data cards are in the aero element coordinate system.
2. If cranks and/or control surfaces exist, their locations are given on the PAERØ3 data card.
3. The numbering system and coordinate system are shown on the next page.

CAERØ3 (Cont.)



The following twelve points are defined for each Mach Box lifting surface.

Planform Corners

1. Leading edge, inboard
2. Trailing edge, inboard
3. Trailing edge, outboard
4. Leading edge, outboard

Cranks

5. Leading edge
6. Trailing edge

Control

7. Hinge line, inboard
8. On inboard edge (usually at trailing edge)
9. Hinge line, outboard
10. On outboard edge

Control (if two)

9. Hinge line, inboard
10. On inboard edge (usually at trailing edge)
11. Hinge line, outboard
12. On outboard edge (usually at trailing edge)

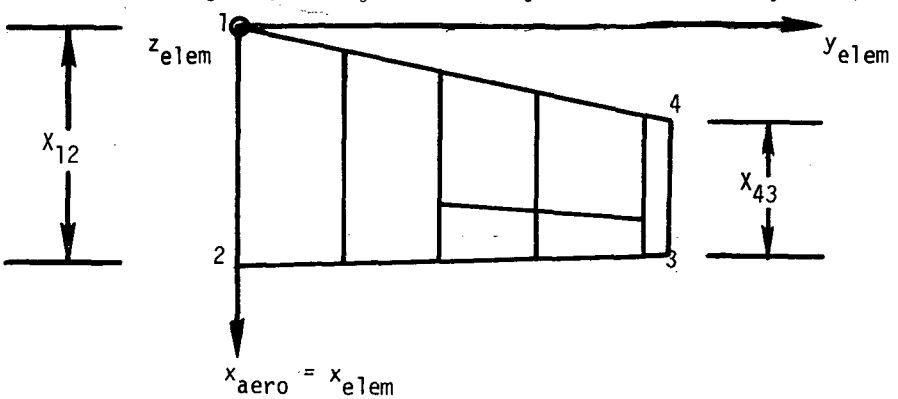
Input Data Card CAERØ4 Aerodynamic Macro-Strip Element Connection

Description: Defines an aerodynamic macro element for strip theory.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CAERØ4	EID	PID	CP	NSPAN	LSPAN				ABC
CAERØ4	6000	6001	100		315				abc
+BC	X1	Y1	Z1	X12	X4	Y4	Z4	X43	
+bc	0.0	0.0	0.0	1.0	0.2	1.0	0.0	0.8	

Field	Contents
EID	Element identification number (Integer > 0)
PID	Property identification number (Integer > 0)
CP	Coordinate system for locating points 1 and 4 (Integer ≥ 0)
NSPAN	Number of strips; if a positive value is given, NSPAN equal strips are assumed. If zero or blank, use LSPAN field (Integer ≥ 0).
LSPAN	ID of an AEFACT data card containing a list of division points for strips. Used only if field 5 is zero or blank (Integer > 0 if NSPAN is zero or blank).
X1,Y1,Z1 X4,Y4,Z4	Location of points 1 and 4 in coordinate system CP (Real)
X12,X43	Edge chord lengths in aerodynamic coordinate system (Real ≥ 0, and not both zero).



Remarks:

1. The strips are numbered sequentially, beginning with EID. The user must ensure that all strip numbers are unique and different from structural grid ID's.
2. The number of division points is one greater than the number of boxes. Thus, if NSPAN = 3, the division points are 0.0, 0.333, 0.667, 1.000. If the user supplies division points, the first and last points need not be 0. and 1. (in which case the corners of the panel would not be at the reference points).
3. A triangular element is formed if X12 or X43 = 0.

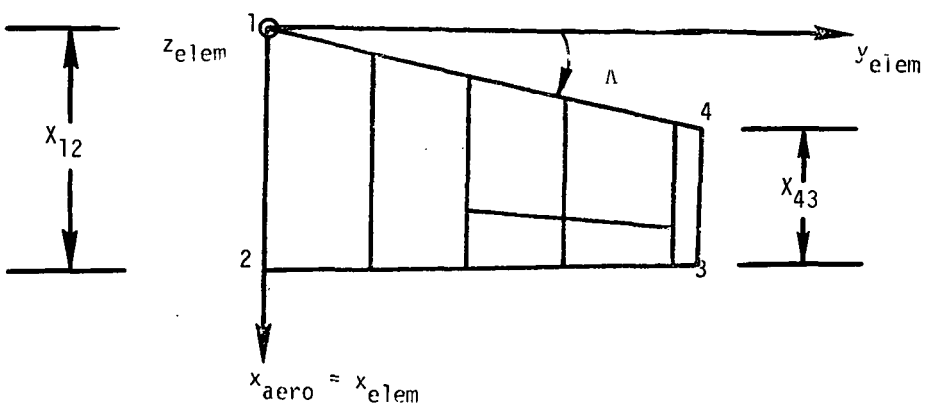
Input Data Card CAERØ5 Aerodynamic Macro-Piston Theory Element Connection

Description: Defines an aerodynamic macro-element for Piston Theory.

Format and Example:

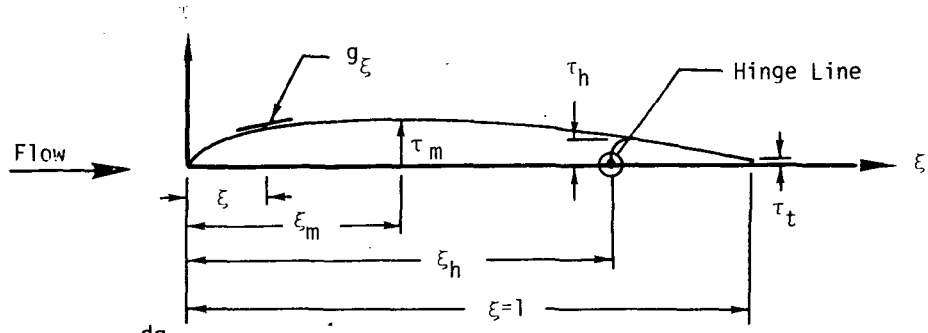
1	2	3	4	5	6	7	8	9	10
CAERØ5	EID	PID	CP	NSPAN	LSPAN	NTHRY	NTHICK		ABC
CAERØ5	6000	6001	100		315	0	0		abc
+BC	X1	Y1	Z1	X12	X4	Y4	Z4	X43	
+bc	0.0	0.0	0.0	1.0	0.2	1.0	0.0	0.8	

Field	Contents
EID	Element identification number (Integer > 0).
PID	Property identification number (Integer > 0).
CP	Coordinate system for locating points 1 and 4 (Integer ≥ 0).
NSPAN	Number of strips; if a positive value is given, NSPAN equal strips are assumed. If zero or blank, use LSPAN field.
LSPAN	ID of an AEFACT data card containing a list of division points for strips. Used only if field 5 is zero or blank (Integer > 0 if NSPAN is zero or blank).
NTHRY	Parameter to select the theory (Integer 0, blank, 1, or 2). See Remark 4. 0 - Use Piston Theory. 1 - Use Van Dyke Theory (no sweep correction, secΛ = 1.). 2 - Use Van Dyke theory with sweep correction.
NTHICK	Parameter to select thickness integrals input (Integer ≥ 0 or blank). 0 - Thickness integrals are computed internally. >0 - Thickness integrals are input directly and is the ID number of AEFACT data card which lists the I and/or J integrals.
X1,Y1,Z1 X4,Y4,Z4	Location of points 1 and 4 in coordinate system CP (Real).
X12,X43	Edge chord lengths in aerodynamic coordinate system (Real ≥ 0, and not both zero).



Remarks:

1. The strips are numbered sequentially, beginning with EID. The user must ensure that all strip numbers are unique and different from structural grid ID's.
2. The number of division points is one greater than the number of boxes. Thus, if NSPAN = 3, the division points are 0.0, 0.333, 0.667, 1.000. If the user supplies division points, the first and last points need not be 0. and 1. (in which the corners of the panel would not be at the reference points).
3. A triangular element is formed if X12 or X43 = 0.
4. Three separate "piston theory" formulations are available (see Section 1.11.2.5).
5. I and J thickness integral definitions:



$g_\xi \equiv \frac{dg}{d\xi}$ = slope of airfoil semithickness

$$I_1 = \int_0^1 g_\xi d\xi \qquad J_1 = \int_{\xi_h}^1 g_\xi d\xi$$

$$I_2 = \int_0^1 \xi g_\xi d\xi \qquad J_2 = \int_{\xi_h}^1 \xi g_\xi d\xi$$

$$I_3 = \int_0^1 \xi^2 g_\xi d\xi \qquad J_3 = \int_{\xi_h}^1 \xi^2 g_\xi d\xi$$

$$I_4 = \int_0^1 g_\xi^2 d\xi \qquad J_4 = \int_{\xi_h}^1 g_\xi^2 d\xi$$

$$I_5 = \int_0^1 \xi g_\xi^2 d\xi \qquad J_5 = \int_{\xi_h}^1 \xi g_\xi^2 d\xi$$

$$I_6 = \int_0^1 \xi^2 g_\xi^2 d\xi \qquad J_6 = \int_{\xi_h}^1 \xi^2 g_\xi^2 d\xi$$

See PAERØ5 for a method to have these integrals computed internally.

Input Data Card CNGRNT Identical Elements Indicator

Description: Designates secondary element(s) identical to a primary element.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CNGRNT	PRID	SECID1	SECID2	SECID3	SECID4	SECID5	SECID6	SECID7	abc
CNGRNT	11	2	17	34	35	36			
+bc	SECID8	SECID9		-etc.-					

Alternate Form

CNGRNT	PRID	SECID1	"THRU"	SECID2					
CNGRNT	7	10	THRU	55					

Field	Contents
PRID	Identification number of the primary element (not necessarily the lowest number)
SECIDi	Identification number(s) of secondary element(s) whose matrices will be identical (or congruent) to those of the primary element.

Remarks:

1. Orientation, geometry, etc. must be truly identical such that the same stiffness, mass and damping matrices are generated in the global coordinate system.
2. This feature is automatically used by the INPUT module.
3. The CNGRNT feature cannot be used when an AXIC card is present in the bulk data deck.
4. An element that has been listed as a primary ID on a CNGRNT card cannot be listed as a secondary ID on another CNGRNT card. However, if the element is listed as a secondary ID on the same card, then such secondary IDs are ignored.
5. The same secondary IDs cannot be listed as congruent to two or more different primary IDs.
6. Redundant specifications on CNGRNT cards are ignored.
7. The stiffness, mass and damping matrices are actually calculated for the lowest numbered element in the congruent set (even though this element may not be the primary ID).

Input Data Card CØNCT1 Substructure Connectivity

Description: Defines the grid point and degree of freedom connectivities between two or more substructures for a manual CØMBINE operation.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CØNCT1	SID	NAME1	NAME2	NAME3	NAME4	NAME5	NAME6	NAME7	def
CØNCT1	805	WINGRT	FUSELAGE	MIDWG	PØD				DEF
+ef	C1	G11	G12	G13	G14	G15	G16	G17	hij
+EF	123	528	17	32	106				HIJ
+ij	C2	G21	G22	G23	G24	G25	G26	G27	
+IJ	46	518							etc.

Field	Contents
SID	Identification number of connectivity set (Integer > 0)
NAMEi	Basic substructure name (BCD)
Ci	Component number - Any unique combination of the digits 1 - 6 (with no imbedded blanks) when the Gi are grid points, or null if they are scalar points.
Gij	Grid or scalar point identification number in substructure namej with components Ci (Integer > 0)

Remarks:

1. At least one continuation card must be present.
2. Components specified on CØNCT1 card will not be overridden by RELES cards.
3. Several CØNCT and CØNCT1 cards may be input with the same value of SID.
4. An alternate format is given by the CØNCT card.
5. Connectivity sets must be selected in the Substructure Control Deck (CØNNECT=SID) to be used by NASTRAN. Note that 'CØNNECT' is a subcommand of the substructure CØMBINE command.
6. The NAMEi's must be the names of basic substructure components of the pseudostructure named on the CØMBINE card in the Substructure Control Deck. See the CØNCT card for a more complete discussion related to the combination of two substructures.
7. This card and its continuations effectively describe a map of connectivities. Grid points entered in the corresponding field of a substructure name define the connectivity participation for that substructure. Each continuation card defines the connection relationships among the participating substructures for the components entered.

Input Data Card CRIGD2 Rigid Element Connection

Description: Defines a rigid element in which selected degrees of freedom of the dependent grid points are coupled to all six degrees of freedom of the reference grid point.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CRIGD2	EID	IG	G1	C1	G2	C2	G3	C3	abc
CRIGD2	102	20	9	12	45	123	53	135	123
+bc	G4	C4	etc.						
+23	27	456							

Field	Contents
EID	Element identification number (Integer > 0)
IG	Identification number of the reference grid point (Integer > 0)
Gi	Identification numbers of the dependent grid points (Integer > 0)
Ci	List of selected degrees of freedom associated with the preceding dependent grid point (any of the digits 1-6 with no imbedded blanks)

Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.
2. Only one reference grid point is allowed per element. It must appear before the dependent grid point data.
3. Any number of dependent grid points may be specified.
4. Dependent degrees of freedom defined for a RIDG2 element may not appear on ØMIT, ØMIT1, SPC, SPC1 or SUPØRT cards nor may they be redundantly implied on ASET or ASET1 cards. They also may not appear as dependent degrees of freedom for RIGD1, RIGD3, or RIGDR elements or on MPC cards.
5. Rigid elements are not allowed in heat transfer analysis.
6. For a discussion of rigid elements, see Section 3.5.6 of the Theoretical Manual.

Input Data Card CRIGD3 General Rigid Element Connection

Description: Defines a rigid element in which selected degrees of freedom of the dependent grid points are coupled to six selected degrees of freedom at one or more (up to six) reference grid points.

Format and Example

1	2	3	4	5	6	7	8	9	10
CRIGD3	EID	IG1	IC1	IG2	IC2	IG3	IC3		abc
CRIGD3	103	11	1	12	2	13	4		ABC
+bc		IG4	IC4	IG5	IC5	IG6	IC6		def
+BC		14	35	15	6				DEF
+ef	"MSET"	DG1	DC1	DG2	DC2	DG3	DC3		ghi
+EF	MSET	21	123	22	1	23	123456		GHI
+hi		DG4	DC4	DG5	DC5	etc.			
+HI		24	456	25	2				

Field	Contents
EID	Element identification number (Integer > 0)
IGi	Identification numbers of the reference grid points (Integer > 0)
ICi	List of selected degrees of freedom associated with the preceding reference grid point (any of the digits 1-6 with no imbedded blanks)
"MSET"	BCD string that indicates the start of the data for the dependent grid points
DGi	Identification numbers of the dependent grid points (Integer > 0)
DCi	List of selected degrees of freedom associated with the preceding dependent grid point (any of the digits 1-6 with no imbedded blanks)

Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.
2. The total number of degrees of freedom specified for the reference grid points (IC1 through IC6) must be six. Further, they should together be capable of representing any general rigid body motion of the element.
3. The first continuation card is not required if less than four reference grid points are specified.
4. The BCD word MSET is required in order to indicate the start of the dependent grid point data.
5. Any number of dependent grid points may be specified.
6. Dependent degrees of freedom defined for a RIGD3 element may not appear on ØMIT, ØMIT1, SPC, SPC1 or SUPØRT cards nor may they be redundantly implied on ASET or ASET1 cards. They also may not appear as dependent degrees of freedom for RIGD1, RIGD2, or RIGDR elements or on MPC cards.

CRIGD3 (Cont.)

7. Rigid elements are not allowed in heat transfer analysis.

8. For a discussion of rigid elements, see Section 3.5.6 of the Theoretical Manual.

Input Data Card DAREAS Dynamic Load Scale Factor - Substructure Analysis

Description: This card is used in conjunction with the RLØAD1, RLØAD2, TLØAD1, and TLØAD2 data cards and defines the point where the dynamic load is to be applied with the scale (area) factor A.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DAREAS	SID	NAME	P	C	A	P	C	A	
DAREAS	3	SKIN	6	2	8.2	15	1	10.1	

Field	Contents
SID	Identification number of DAREA set (Integer > 0)
NAME	Basic substructure name
P	Grid or scalar point identification number (Integer > 0)
C	Component number (1-6 for grid point; blank or 0 for scalar point)
A	Scale (area) factor A for the designated coordinate (Real)

Remarks:
1. One or two scale factors may be defined on a single card
2. Used in substructure SØLVE operation
3. Points referenced must exist in the SØLVEd structure.

Input Data Card DELAYS Dynamic Load Time Delay - Substructure Analysis

Description: This card is used in conjunction with the RLØAD1, RLØAD2, TLØAD1 and TLØAD2 data cards and defines the time delay term τ in the equations of the loading function.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DELAYS	SID	NAME	P	C	T	P	C	T	
DELAYS	5	SKIN	21	6	4.25	7	6	8.1	

Field	Contents
SID	Identification number of DELAY set (Integer > 0)
NAME	Basic substructure name
P	Grid or scalar point identification number (Integer > 0)
C	Component number (1-6 for grid point, blank or 0 for scalar point)
T	Time delay τ for designated coordinate (Real)

Remarks:
1. One or two dynamic load time delays may be defined on a single card.
2. Used in substructure SOLVE operation.
3. Points referenced must exist in the SØLVEd structure.

Input Data Card DPHASES Dynamic Load Phase Lead - Substructure Analysis

Description: This card is used in conjunction with the RLØAD1 and RLØAD2 data cards to define the phase lead term θ in the equation of the loading function.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DPHASES	SID	NAME	P	C	TH	P	C	TH	
DPHASES	4	SKIN	21	6	2.1	8	6	7.2	

Field	Contents
SID	Identification number of DPHASE set (Integer > 0)
NAME	Basic substructure name
P	Grid or scalar point identification number (Integer > 0)
C	Component number (1-6 for grid point, 0 or blank for scalar point)
TH	Phase lead θ (in degrees) for designated coordinate (Real)

Remarks:
1. One or two dynamic load phase lead terms may be defined on a single card.
2. Used in substructure SØLVE operation.
3. Points referenced must exist in the SØLVEd structure.

Input Data Card FLFACT Aerodynamic Physical Data

Description: Used to specify densities, Mach numbers, and reduced frequencies for flutter analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FLFACT	SID	F1	F2	F3	F4	F5	F6	F7	ABC
FLFACT	97	.3	.7	3.5					abc
+BC	F8	F9	--etc.--						

Alternate Form:

FLFACT	SID	F1	THRU	FNF	NF	FMID			
FLFACT	201	.200	THRU	.100	11	.133333			

Field	Contents
SID	Set identification number (Unique Integer > 0).
Fi	Aerodynamic factor (Real).

Remarks:

1. These factors must be selected by a FLUTTER data card to be used by NASTRAN.
2. Imbedded blank fields are forbidden.
3. Parameters must be listed in the order in which they are to be used within the looping of flutter analysis.
4. For the alternate form, NF must be greater than 1. F_{mid} must lie between F_1 and F_{NF}, otherwise F_{mid} will be set to $(F_1 + F_{NF})/2$. Then

$$F_i = \frac{F_1(F_{NF}-F_{mid})(NF-i) + F_{NF}(F_{mid}-F_1)(i-1)}{(F_{NF}-F_{mid})(NF-i) + (F_{mid}-F_1)(i-1)} \qquad i = 1,2,\ldots,NF$$

The use of F_{mid} (middle factor selection) allows unequal spacing of the factors. $F_{mid} = 2F_1F_{NF}/(F_1+F_{NF})$ gives equal values to increments of the reciprocal of F_1.

Input Data Card FLUTTER Aerodynamic Flutter Data

Description: Defines data needed to perform flutter analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FLUTTER	SID	METHØD	DENS	MACH	RFREQ	IMETH	NVALUE	EPS	
FLUTTER	19	K	119	219	319	S	5	1.-4	

Field	Contents
SID	Set identification number (Unique Integer > 0).
METHØD	Flutter analysis method, "K" for K-method, "PK" for P-K method, "KE" for the K-method restricted for efficiency.
DENS	Identification number of an FLFACT data card specifying density ratios to be used in flutter analysis (Integer $\geq$ 0).
MACH	Identification number of an FLFACT data card specifying Mach numbers (m) to be used in flutter analysis (Integer $\geq$ 0).
RFREQ (or VEL)	Identification number of an FLFACT data card specifying reduced frequencies (k) to be used in flutter analysis (Integer > 0); for the p-k method, the velocity.
IMETH	Choice of interpolation method for matrix interpolation (BCD: L = linear, S = surface).
NVALUE	Number of eigenvalues for output and plots (Integer > 0).
EPS	Convergence parameter for k; used in the P-K method (Real)(default = 10^{-3}).

Remarks:
1. The FLUTTER data card must be selected in Case Control Deck (FMETHOD = SID).
2. The density is given by DENS · RHØREF, where RHØREF is the reference value given on the AERØ data card.
3. The reduced frequency is given by k = (REFC·ω/2·V), where REFC is given on the AERØ data card, ω is the circular frequency and V is the velocity.
4. An eigenvalue is accepted in the P-K method when $|k - k_{estimate}| < EPS$.

Input Data Card GUST Aerodynamic Gust Load Description

Description: Defines a stationary vertical gust for use in aeroelastic analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
GUST	SID	DLØAD	WG	XO	V				
GUST	133	61	1.0	0.	1.+4				

Field	Contents
SID	Gust set identification number (Integer > 0).
DLØAD	The SID of a TLØAD or RLØAD data card which defines the time or frequency dependence (Integer > 0).
WG	Scale factor (gust velocity/forward velocity) for gust velocity (Real $\neq$ 0.).
XO	Location of reference plane in aerodynamic coordinates (Real $\geq$ 0.0).
V	Velocity of vehicle (Real > 0.0).

Remarks:

1. The GUST card is selected in Case Control by GUST=SID.
2. The gust angle is in the +z direction of the aerodynamic coordinate system. The value is

$$WG \cdot T\left(t - \frac{x-x_0}{V}\right) ,$$

where T is the tabular function.

3. In random analysis, a unit gust velocity (WG=1/velocity) is suggested. The actual rms value is entered on the TABRNDG data card.
4. XO and V may not change between subcases under one execution.

Input Data Card MAT1 Material Property Definition

Description: Defines the material properties for linear, temperature-independent, isotropic materials.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MAT1	MID	E	G	NU	RHØ	A	TREF	GE	+abc
MAT1	17	3.+7	1.9+7		4.28	0.19	5.37+2	0.23	ABC
+abc	ST	SC	SS	MCSID					
+BC	20.+4	15.+4	12.+4	2004					

Field	Contents
MID	Material identification number (Integer > 0)
E	Young's modulus (Real ≥ 0.0 or blank)
G	Shear modulus (Real ≥ 0.0 or blank)
NU	Poisson's ratio (-1.0 < Real ≤ 0.5 or blank)
RHØ	Mass density (Real)
A	Thermal expansion coefficient (Real)
TREF	Thermal expansion reference temperature (Real)
GE	Structural element damping coefficient (Real)
ST, SC, SS	Stress limits for tension, compression and shear (Real) (Required for Property Optimization calculations; otherwise optional if margins of safety are desired.)
MCSID	Material coordinate system identification number (Integer ≥ 0 or blank)

Remarks:

1. One of E or G must be positive (i.e., either E > 0.0 or G > 0.0 or both E and G may be > 0.0).
2. If any one of E, G or NU is blank, it will be computed to satisfy the identity E = 2(1+NU)G; otherwise, values supplied by the user will be used.
3. The material identification number must be unique for all MAT1, MAT2 and MAT3 cards.
4. MAT1 materials may be made temperature dependent by use of the MATT1 card.
5. The mass density, RHØ, will be used to automatically compute mass for all structural elements except the two-dimensional bending only elements TRBSC, TRPLT and QDPLT.
6. If E and NU or G and NU are both blank they will be both given the value 0.0.
7. Weight density may be used in field 6 if the value $\frac{1}{g}$ is entered on the PARAM card WTMASS, where g is the acceleration of gravity.
8. Solid elements must not have NU equal to 0.5.
9. Entries for A (thermal expansion coefficient) and TREF (reference temperature) are assumed to be 0.0 when blank. In a heat formulation, A must be overridden by an appropriate entry; TREF may be overridden if desired.
10. MCSID (> 0) is required if stresses or strains/curvatures are to be computed in a material coordinate system. This is applicable only for TRIA1, TRIA2, QUAD1, and QUAD2 elements.

Input Data Card MAT2 Material Property Definition

Description: Defines the material properties for linear, temperature-independent, anisotropic materials.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MAT2	MID	G11	G12	G13	G22	G23	G33	RHO	+abc
MAT2	13	6.2+3			6.2+3		5.1+3	0.056	ABC
+abc	A1	A2	A12	TO	GE	ST	SC	SS	+def
+BC	0.15			-500.0	0.002	20.+5			DEF
+def	MCSID								
+EF	1008								

Field	Contents
MID	Material identification number (Integer > 0)
Gij	The material property matrix (Real)
RHØ	Mass density (Real)
Ai	Thermal expansion coefficient vector (Real)
TO	Thermal expansion reference temperature (Real)
GE	Structural element damping coefficient (Real)
ST, SC, SS	Stress limits for tension, compression and shear (Real) (Used only to compute margins of safety in certain elements; they have no effect on the computational procedures)
MCSID	Material coordinate system identification number (Integer $\geq$ 0 or blank)

Remarks:

1. The material identification numbers must be unique for all MAT1, MAT2 and MAT3 cards.
2. MAT2 materials may be made temperature dependent by use of the MATT2 card.
3. The mass density, RHØ, will be used to automatically compute mass for all structural elements except the two-dimensional bending only elements TRBSC, TRPLT and QDPLT.
4. The convention for the G_{ij} in fields 3 through 8 is represented by the matrix relationship.

$$\begin{Bmatrix} \sigma_1 \\ \sigma_2 \\ \tau_{12} \end{Bmatrix} = \begin{bmatrix} G_{11} & G_{12} & G_{13} \\ G_{12} & G_{22} & G_{23} \\ G_{13} & G_{23} & G_{33} \end{bmatrix} \cdot \begin{Bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \gamma_{12} \end{Bmatrix}$$

5. MCSID (> 0) is required if stresses or strains/curvatures are to be computed in a material coordinate system. This is applicable only for TRIA1, TRIA2, QUAD1, and QUAD2 elements.

Input Data Card PAERØ1 Aerodynamic Panel Property

Description: Gives associated bodies for the panels in the Doublet-Lattice method.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PAERØ1	PID	B1	B2	B3	B4	B5	B6		
PAERØ1	1	3							

Field	Contents
PID	Property identification number (referenced by CAERØ1) (Integer > 0).
B1,..., B6	ID of associated body (Integer ≥ 0 or blank).

Remarks:
1. The associated body must be in the same aerodynamic group (IGID).
2. If there are no bodies, the card is still required.
3. The Bi numbers above must appear on a PAERØ2 card to define these bodies completely.

Input Data Card PAERØ2 Aerodynamic Body Properties

Description: Defines the cross-section properties of aerodynamic bodies.

Format and Example:

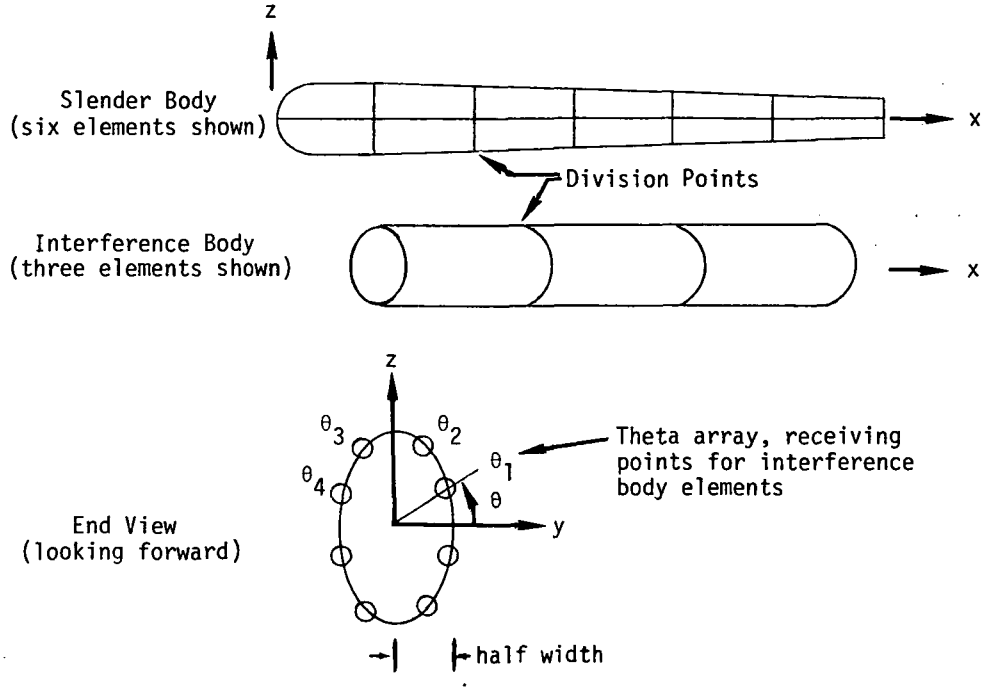
1	2	3	4	5	6	7	8	9	10
PAERØ2	PID	ØRIENT	WIDTH	AR	LRSB	LRIB	LTH1	LTH2	ABC
PAERØ2	2	Z	6.0	1.0	22	91	100		abc
+BC	THI1	THN1	THI2	THN2	THI3	THN3	etc.		
+bc	1	3							

Field	*Contents*
PID	Property identification number (Integer > 0).
ØRIENT	Orientation flag "Z," "Y" or "ZY." Type of motion allowed for bodies (BCD). Refers to the aerodynamic coordinate system y direction of ACSID (see AERØ data card).
WIDTH	Reference half-width of body (Real > 0.).
AR	Aspect ratio (height/width) (Real > 0.).
LRSB	ID of an AEFACT data card containing a list of slender body half-widths. If blank, the value of WIDTH will be used (Integer ≥ 0 or blank).
LRIB	ID of an AEFACT data card containing a list of interference body half-widths. If blank, the value of WIDTH will be used (Integer ≥ 0 or blank).
LTH1, LTH2	ID of AEFACT data cards for defining theta arrays for interference calculations (Integer ≥ 0 or blank).
THIi, THNi	The first and last inteference element of a body to use the θ_i array (Integer ≥ 0).

Remarks:

1. The EID of all CAERØ2 elements in any IGID group must be ordered, so that their corresponding ØRIENT values appear in the order Z, ZY, Y.
2. The half-widths (given on AEFACT data cards referenced in field 6 and 7) are specified at division points. The number of entries on an AEFACT data card used to specify half-widths must be one greater than the number of elements.
3. The half-width at the first point (i.e., the nose) on a slender body is usually 0.; thus it is recommended (but not required) that the LRSB data is supplied with a zero first entry.
4. THIi and THNi are interference element locations on a body. The first element is one for each body.

5. A body is represented by a slender body surrounded by an interference body. The slender body creates the downwash due to the motion of the body, while the interference body represents the effects upon panels and other bodies. The cross-section is elliptical.



Input Data Card PAERØ3 Aerodynamic Mach Box Surface Properties

Description: Defines the number of Mach boxes in the flow direction and the location of cranks and control surfaces of a Mach box lifting surface.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PAERØ3	PID	NBØX	NCTRL		X5	Y5	X6	Y6	ABC
PAERØ3	2001	15	2		0.	65.			abc
+BC	X7	Y7	X8	Y8	X9	Y9	X10	Y10	DEF
+bc	78.	65.	108.	65.	82.	97.5	112.	97.5	def
+EF	X11	Y11	X12	Y12					
+ef	86.	130.	116.	130.					

Field	Contents
PID	Property identification number (Integer > 0).
NBØX	The number of Mach boxes in flow direction (0 < Integer < 50).
NCTRL	Number of control surfaces (Integer 0, 1, or 2).
X5-Y12	Location of points 5 through 12, which are in the element coordinate system, to define the cranks and control surface geometry (Real).

Remarks:

1. The geometry is shown in a figure on the CAERØ3 Bulk Data card description.
2. If Y5 $\leq$ 0.0, there is no leading edge crank. Also, if Y6 $\leq$ 0.0, there is no trailing edge crank.
3. If NCTRL = 0, no continuation cards are needed. If NCTRL = 1 or 2, then NCTRL continuation cards are needed.
4. The relations Y7 $\geq$ Y8, Y9 $\geq$ Y10, and Y11 $\geq$ Y12 must hold.

Input Data Card PAERØ4 Aerodynamic Supersonic Strip Properties

Description: Gives properties of each strip element for the strip theory.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PAERØ4	PID	CLA	LCLA	CIRC	LCIRC	DØC1	CAØC1	GAPØC1	ABC
PAERØ4	6001	1	501	0	0	0.0	0.0	0.0	abc
+BC	DØC2	CAØC2	GAPØC2	DØC3	CAØC3	GAPØC3		etc. . .	. .
+bc	0.50	0.25	0.02	0.53	0.24	0.0			

Field	Contents
PID	Property identification number (Integer > 0).
CLA	Parameter to select Prandtl-Glauert correction (Integer -1, 0, 1, or blank). -1 - compressibility correction made to lift curve slope data for a reference Mach number. 0 or blank - no correction and no list needed. +1 - no correction and lift curve slope provided by a list as a function of strip location and Mach number.
LCLA	ID number of AEFACT data card which lists the lift curve slope on all strips for each Mach number on MKAERØi data card (Integer = 0 if CLA = 0, > 0 if CLA ≠ 0) (see Remark 7(b) below).
CIRC	Parameter to select Theodorsen's function, C(k), or the number of exponential coefficients used to approximate C(k) (Integer 0, 1, 2, 3, or blank. Must be zero if CLA ≠ 0). 0 or blank - Theodorsen function. 1,2,3 - approximate function with b_0, b_1, β_1, ... b_n, β_n) n = 1,2,3.
LCIRC	ID number of AEFACT data card which lists the b, β values for each Mach number on the MKAERØi data card (Integer = 0 if CIRC = 0, > 0 if CIRC ≠ 0) (see Remarks 7(c), 7(d), and 7(e) below; variable b's and β's for each m).
DØCi	d/c = distance of control surface hinge aft of quarter-chord divided by the strip chord (Real ≥ 0.0).
CAØCi	c_a/c = control surface chord divided by the strip chord (Real ≥ 0.0).
GAPØCi	g/c = control surface gap divided by the strip chord (Real ≥ 0.0).

Remarks:
1. This card is required for strip theory with three entries (DØCi, CAØCi, GAPØCi) per strip.
2. If CLA = -1, lift curve slope data at one Mach number are needed on the AEFACT data card.
3. If CAØCi = 0.0, there is no control surface.
4. If GAPØCi = 0.0, there is slot flow.
5. If GAPØCi < 0.01, then 0.01 is used.

6. Imbedded blank fields are not allowed.

7. The following table lists the lift curve slope or lag function selection and the AEFACT data card formats used for strip theory.

Theodorsen Function	Data Type Input	Parameter Combinations				Number of Words	Card Format Index
		CLA	LCLA	CIRC	LCIRC		
Exact	Lift Curve Slope $c_{\ell_{\alpha i}}=2\pi$	0	0	0	0	No AEFACT card required	
	$c_{\ell_{\alpha i}}$ input, uses Prandtl-Glauert Corr.	-1	ID	0	0	(NSTRIP+1)	(a)
	$c_{\ell_{\alpha i}}$ input, for all m's on MKAERØ card	1	ID	0	0	(NSTRIP+1)*NMACH	(b)
Approximate	Coefficients - b_{0i}, b_{1i}, β_{1i}, etc.	0	0	1	ID	4*NMACH	(c)
		0	0	2	ID	6*NMACH	(d)
		0	0	3	ID	8*NMACH	(e)

Card Format

(a) AEFACT, ID, m_1, $c_{\ell_{\alpha_1}}$, $c_{\ell_{\alpha_2}}$, ..., $c_{\ell_{\alpha_{NSTRIP}}}$

(b) AEFACT, ID, m_1, $c_{\ell_{\alpha_{11}}}$, $c_{\ell_{\alpha_{21}}}$, ..., $c_{\ell_{\alpha_{NSTRIP1}}}$, m_2, $c_{\ell_{\alpha_{12}}}$, $c_{\ell_{\alpha_{22}}}$, ..., $c_{\ell_{\alpha_{NSTRIP2}}}$,

etc., for all m on MKAERØi data card.

(c) AEFACT, ID, m_1, b_{01}, b_{11}, β_{11}, m_2, b_{02}, b_{12}, β_{12}, m_3, etc.

(d) AEFACT, ID, m_1, b_{01}, b_{11}, β_{11}, b_{21}, β_{21}, m_2, etc.

(e) AEFACT, ID, m_1, b_{01}, b_{11}, β_{11}, b_{21}, β_{21}, b_{31}, β_{31}, m_2, etc.

Input Data Card PAERØ5 Aerodynamic Strip Element Properties

Description: Gives properties of each strip element for Piston Theory.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PAERØ5	PID	NALPHA	LALPHA	NXIS	LXIS	NTAUS	LTAUS		ABC
PAERØ5	7001	1	702	1	701	1	700		abc
+BC	CAØC1	CAØC2	CAØC3	CAØC4	CAØC5	etc. . .			
+bc	0.0	0.0	5.25	3.99375	0.0				

Field	Contents
PID	Property identification number (Integer > 0).
NALPHA	Number of angles of attack (α) input per Mach number (m, of MKAERØi data card) (Integer > 0) (see Remark 3 below).
LALPHA	ID number of the required AEFACT data card which lists the α's (Integer > 0).
NXIS	Number of dimensionless chordwise coordinates (ξ) used to define the geometry of the strips (Integer $\geq$ 0 or blank) (see Remark 4 below).
LXIS	ID number of the AEFACT data card which lists the ξ's (Integer = 0 if Ca = 0, NTHICK > 0, Integer > 0 if Ca > 0, NTHICK = 0) where Ca is control surface chord length.
NTAUS	Number of thickness ratios (τ) used to define the geometry of the strips (Integer $\geq$ 0 or blank).
LTAUS	ID number of the AEFACT data card which lists the τ's (Integer = 0 or blank if NTAUS = 0, Integer > 0 if NTAUS > 0).
CAØCi	Ratio of chord of control surface to chord of strip (Ca/c) for each strip (Real $\geq$ 0).

Remarks:

1. A PAERØ5 card is used for piston theory strip property definition and is referenced in the PID column of a CAERØ5 card.
2. The continuation card is required. The number of entries must equal the number of strips (from CAERØ5). Imbedded blank fields are forbidden, so use 0.0 if there is no control surface.
3. The following table lists the formats of the AEFACT data cards for angle of attack distribution.

TYPE OF DATA	NALPHA	LALPHA FORMAT
Same α for all strips	1	(a)
Variable α	NSTRIP	(b)

Format	Number of Words	
(a)	2*NMACH	AEFACT, ID, m_1, α_1, m_2, α_2, ...
(b)	(1+NSTRIP) *NMACH	AEFACT, ID, m_1, α_{11}, α_{21}, ..., $\alpha_{NSTRIP,1}$, ... (repeat for all m's)

4. The following table lists the formats of the AEFACT data cards for thickness and other list data.

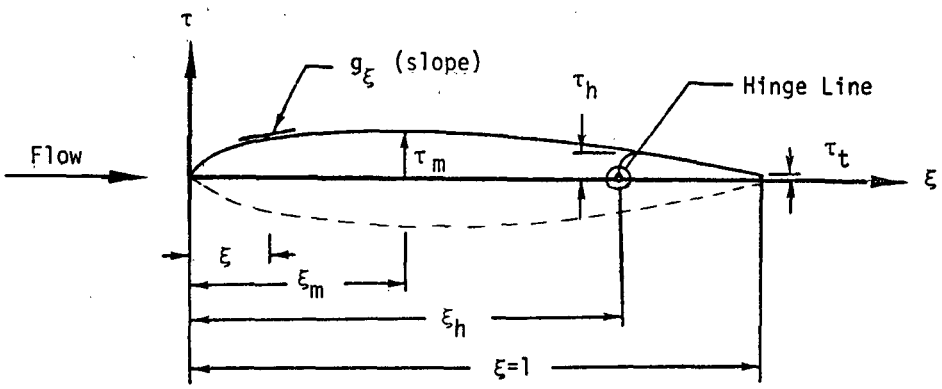
TYPE OF INPUT DATA	CAØCi	NTHICK FORMAT	NXIS	LXIS FORMAT	NTAUS	LTAUS FORMAT
Integrals are input						
Same for all strips, no control surfaces	0.	(c)	0	0	0	0
Same for all strips with control surfaces	≠0.	(d)	1	(e)	0	0
Separate hinge for each strip with control surfaces	≠0.	(d)	NSTRIP	(f)	0	0
Thickness data are input						
Same for all strips, no control surfaces	0.	0	1	(g)	1	(h)
Same for all strips with control surfaces	≠0.	0	1	(g)	1	(h)
Separate data for each strip with control surfaces	≠0.	0	NSTRIP	(i)	NSTRIP	(j)

Format	Number of Words	
(c)	6	AEFACT, ID, I_1, I_2, I_3, I_4, I_5, I_6
(d)	12	AEFACT, ID, I_1, ..., I_6, J_1, ..., J_6
(e)	1	AEFACT, ID, ξ_h
(f)	NSTRIP	AEFACT, ID, ξ_{h1}, ξ_{h2}, ..., $\xi_{h_{NSTRIP}}$
(g)	2	AEFACT, ID, ξ_m, ξ_h
(h)	3	AEFACT, ID, τ_m, τ_h, τ_t

Format	Number of Words	
(i)	2*NSTRIP	AEFACT, ID, ξ_{m1}, ξ_{h1}, ..., $\xi_{h_{NSTRIP}}$
(j)	3*NSTRIP	AEFACT, ID, τ_{m1}, τ_{h1}, τ_{t1}, ..., $\tau_{t_{NSTRIP}}$

Note: If there is no hinge, you may put $\xi_h = \tau_h = 0$.

Dimensions of symmetrical airfoil, internal integral calculation:



. MAXIT - optional in nonlinear static HEAT transfer analysis (rigid format 3). The integer value of this parameter limits the maximum number of iterations. The default value is 4 iterations.

l. EPSHT - optional in nonlinear static HEAT transfer analysis (rigid format 3). The real value of this parameter is used to test the convergence of the nonlinear heat transfer solution (see Section 8.4.1 of the Theoretical Manual). The default value is .001.

m. TABS - optional in nonlinear static (rigid format 3) and transient (rigid format 9) HEAT transfer analysis. The real value of this parameter is the absolute reference temperature. The default value is 0.0.

n. SIGMA - optional in nonlinear static (rigid format 3) and transient (rigid format 9) HEAT transfer analysis. The real value of this parameter is the Stefan-Boltzman constant. The default value is 0.0.

o. BETA - optional in transient HEAT transfer analysis (rigid format 9). The real value of this parameter is used as a factor in the integration algorithm (see Section 8.4.2 of the Theoretical Manual). The default value is 0.55.

p. RADLIN - optional in transient HEAT transfer analysis (rigid format 9). A positive integer value of this parameter causes some of the radiation effects to be linearized (see Equation 2, Section 8.4.2 of the Theoretical Manual). The default value is -1.

q. BETAD - optional in static analysis with differential stiffness (rigid format 4). The integer value of this parameter is the number of iterations allowed for computing the load correction in the inner (load) loop before shifting to the outer (stiffness) loop which adjusts the differential stiffness. The default value is 4 iterations.

r. NT - optional in static analysis with differential stiffness (rigid format 4). The integer value of this parameter limits the cumulative number of iterations in both loops. The default value is 10 iterations.

s. EPSIØ - optional in static analysis with differential stiffness (rigid format 4). The real value of this parameter is used to test the convergence of iterated differential stiffness. The default value is 10^{-5}.

t. CTYPE - required in cyclic symmetry analysis (rigid formats 14 and 15). The BCD value of this parameter defines the type of cyclic symmetry as follows:

(1) RØT - rotational symmetry
(2) DRL - dihedral symmetry, using right and left halves
(3) DSA - dihedral symmetry, using symmetric and antisymmetric components.

u. NSEGS - required in cyclic symmetry analysis (rigid formats 14 and 15). The integer value of this parameter is the number of identical segments in the structural model.

v. NLØAD - optional in static analysis with cyclic symmetry (rigid format 14). The integer value of this parameter is the number of static loading conditions. The default value is 1.

w. CYCIØ - optional in static analysis with cyclic symmetry (rigid format 14). The integer value of this parameter specifies the form of the input and output data. A value of +1 is used to specify physical segment representation, and a value of -1 for cyclic transform representation. The default value is +1.

x. CYCSEQ - optional in cyclic symmetry analysis (rigid formats 14 and 15). The integer value of this parameter specifies the procedure for sequencing the equations in the solution set. A value of +1 specifies that all cosine terms should be sequenced before all sine terms, and a value of -1 for alternating the cosine and sine terms. The default value is -1.

PARAM (Cont.)

y. KMAX - optional in static analysis with cyclic symmetry (rigid format 14). The integer value of this parameter specifies the maximum value of the harmonic index. The default value is ALL which is NSEGS/2 for NSEGS even and (NSEGS-1)/2 for NSEGS odd.

z. KINDEX - required in normal modes with cyclic symmetry (rigid format 15). The integer value of this parameter specifies a single value of the harmonic index.

aa. NØDJE - optional in AERØ rigid formats. A positive integer of this parameter indicates user supplied downwash matrices due to extra points are to be read from tape via the INPUTT2 module in the rigid format. The default value is -1.

ab. P1, P2, and P3 - required in AERØ rigid formats when using NØDJE parameter. See Section 5.5 for tape operation parameters required by INPUTT2 module. The defaults for P1, P2, and P3 are 0,11, and XXXXXXXX, respectively.

ac. VREF - optional in modal flutter analysis (rigid format 10). Velocities are divided by the real value of this parameter to convert units or to compute flutter indices. The default value is 1.0.

ad. PRINT - optional in modal flutter analysis (rigid format 10). The BCD value, NØ, of this parameter will suppress the automatic printing of the flutter summary for the K method. The default vlaue is YES.

ae. ISTART - optional in direct and modal transient response (rigid formats 9 and 12). A positive value of this parameter will cause the second (or alternate) starting method to be used (see Section 11.3 of the Theoretical Manual). The alternate starting method is recommended when initial accelerations are significant and when the mass matrix is non-singular. The default value is -1 and will cause the first starting method to be used.

af. KDAMP - optional in AERØ rigid formats. An integer value of +1 causes modal damping terms to be put into the complex stiffness matrix for structural damping. The default is -1.

ag. GUSTAERØ - optional in AERØ rigid formats. An integer value of +1 causes gust loads to be computed. The default is -1.

ah. IFTM - optional in aeroelastic response (rigid format 11). The value of this parameter selects the method for the integration of the Inverse Fourier Transform. The integer value 0 specifies a rectangular fit; 1 specifies a trapezoidal fit; and 2 specifies a cubic spline fit to obtain solutions versus time for which aerodynamic forces are functions of frequency. The default value is 0.

ai. MACH - optional in AERØ rigid formats. The real value of this parameter selects the closest Mach numbers to be used to compute aerodynamic matrices. The default is 0.0.

aj. Q - required in aeroelastic response (rigid format 11). The real value of this parameter defines the dynamic pressure.

ak. ØPT - optional in static and normal modes analyses (rigid formats 1, 2, 3, 14, and 15). A positive integer value of this parameter causes both equilibrium and multipoint constraint forces to be calculated for the Case Control output request, MPCFØRCE. A negative integer value of this parameter causes only the equilibrium force balance to be calculated for the output request. The default value is 0 which causes only the multipoint constraint forces to be calculated for the output request.

aℓ. GRDEQ - optional in static and normal modes analyses (rigid formats 1, 2, 3, 14, and 15). A positive integer value of this parameter selects the grid point about which equilibrium will be checked for the Case Control output request, MPCFØRCE. If the integer value is zero, the basic origin is used. Default is -1.

am. STRESS - optional in static analysis (rigid format 1). This parameter controls the transformation of element stresses to the material coordinate system (only for TRIA1, TRIA2, QUAD1 and QUAD2 elements). If it is a positive integer, the stresses for these elements are transformed to the material coordinate system. If it is zero, stresses at the connected grid points are also computed in addition to the element stresses in the material coordinate system. A negative integer value results in no transformation of the stresses. The default value is -1.

an. STRAIN - optional in static analysis (rigid format 1). This parameter controls the transformation of element strains/curvatures to the material coordinate system (only for TRIA1, TRIA2, QUAD1 and QUAD2 elements). If it is a positive integer, the strains/curvatures for these elements are transformed to the material coordinate system. If it is zero, strains/curvatures at the connected grid points are also computed in addition to the element strains/curvatures in the material coordinate system. A negative integer value results in no transformation of the strains/curvatures. The default value is -1.

ao. NINTPTS - optional in static analysis (rigid format 1). A positive integer value of this parameter specifies the number of closest independent points to be used in the interpolation for computing stresses or strains/curvatures at grid points (only for TRIA1, TRIA2, QUAD1 and QUAD2 elements). A negative integer value or 0 specifies that all independent points are to be used in the interpolation. The default value is 0.

Input Data Card RLØAD1 Frequency Response Dynamic Load

Description: Defines a frequency dependent dynamic load of the form

$$\{P(f)\} = \{A[C(f) + iD(f)]\, e^{i\{\theta - 2\pi f\tau\}}\}$$

for use in frequency response problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RLØAD1	SID	L	M	N	TC	TD			
RLØAD1	5	3	6	9	1	2			

Field	Contents
SID	Set identification number (Integer > 0)
L	Identification number of DAREA or DAREAS and LØADC card set which defines A (Integer > 0)
M	Identification number of DELAY or DELAYS card set which defines τ (Integer $\geq$ 0)
N	Identification number of DPHASE or DPHASES card set which defines θ (Integer $\geq$ 0)
TC	Set identification number of TABLEDi card which gives C(f) (Integer $\geq$ 0; TC + TD > 0)
TD	Set identification number pf TABLEDi card which gives D(f) (Integer $\geq$ 0; TC + TD > 0)

Remarks:

1. If any of M, N, TC or TD are blank or zero, the corresponding τ, θ, C(f), or D(f) will be zero
2. Dynamic load sets must be selected in the Case Control Deck (DLØAD=SID) to be used by NASTRAN.
3. RLØAD1 loads may be combined with RLØAD2 loads only by specification on a DLØAD card. That is, the SID on a RLØAD1 card may not be the same as that on a RLØAD2 card.
4. SID must be unique for all RLØAD1, RLØAD2, TLØAD1 and TLØAD2 cards.
5. With automated multi-stage substructuring, DAREAS cards may only reference degrees of freedom in the boundary set of the solution structure.
6. When L references LØADC cards, DAREAS cards with the same set identification and non-zero loads must also exist.

Input Data Card RLØAD2 Frequency Response Dynamic Load

Description: Defines a frequency dependent dynamic load of the form

$$\{P(f)\} = \{AB(f)e^{i\{\phi(f) + \theta - 2\pi f\tau\}}\}$$

for use in frequency response problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RLØAD2	SID	L	M	N	TB	TP			
RLØAD2	5	3	6	21	7	2			

Field	Contents
SID	Set identification number (Integer > 0)
L	Identification number of DAREA or DAREAS and LØADC card set which defines A (Integer > 0)
M	Identification number of DELAY or DELAYS card set which defines τ (Integer $\geq$ 0)
N	Identification number of DPHASE or DPHASES card set which defines θ in degrees (Integer $\geq$ 0)
TB	Set identification number of TABLEDi card which gives B(f) (Integer 0)
TP	Set identification number of TABLEDi card which gives ϕ(f) in degrees (Integer $\geq$ 0)

Remarks:

1. If any of M, N or TP are zero, the corresponding τ, θ or ϕ(f) will be zero.
2. Dynamic load sets must be selected in the Case Control Deck (DLØAD=SID) to be used by NASTRAN.
3. RLØAD2 loads may be combined with RLØAD1 loads only by specification on a DLØAD card. That is, the SID on a RLØAD2 card may not be the same as that on a RLØAD1 card.
4. SID must be unique for all RLØAD1, RLØAD2, TLØAD1 and TLØAD2 cards.
5. With automated multi-stage substructuring, DAREAS cards may only reference degrees of freedom in the boundary set of the solution structure.
6. When L references LØADC cards, DAREAS cards with the same set identification and non-zero loads must also exist.

Input Data Card SET2 Grid Point List

Description: Defines a set of structural grid points in terms of aerodynamic macro elements.

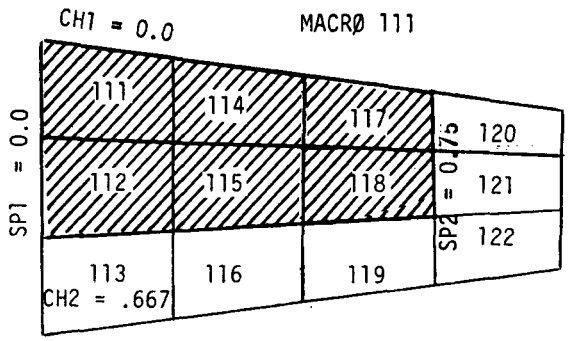
Format and Example:

1	2	3	4	5	6	7	8	9	10
SET2	SID	MACRØ	SP1	SP2	CH1	CH2	ZMAX	ZMIN	
SET2	3	111	.0	.75	0.	.667	1.0	-3.51	

Field	Contents
SID	Set identification number (Integer > 0).
MACRØ	Element identification number of an aero macro element (Integer > 0).
SP1,SP2	Lower and higher span division points defining prism containing set (-.01 < Real < 1.01)
CH1,CH2	Lower and higher chord division points defining prism containing set (-.01 < Real < 1.01)
ZMAX,ZMIN	Top and bottom z coordinates (using right-hand rule with the order the corners as listed on a CAERØ1 card) of the prism containing set (Real). Usually ZMAX $\geq$ 0, ZMIN $\leq$ 0.

Remarks: 1. These cards are referenced by the SPLINEi data cards.

2. Every grid point, within the defined prism and within the height range, will be in the set. For example,



The shaded area in the figure defines the cross-section of the prism for the sample data given above. Points exactly on the boundary may be missed, hence, to get the area of the macro element, use SP1 = -.01, SP2 = 1.01, etc.

3. A zero value for ZMAX or ZMIN implies infinity is to be used.

4. To find the (internal) grid ID's found, use DIAG 18.

Input Data Card SPLINE2 Linear Spline

Description: Defines a beam spline for interpolating panels and bodies for aeroelastic problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPLINE2	EID	CAERØ	ID1	ID2	SETG	DZ	DTØR	CID	ABC
SPLINE2	5	8	12	24	60	0.	1.0	3	abc
+BC	DTHX	DTHY							
+bc	-1.								

Field	Contents
EID	Element identification number (Integer > 0).
CAERØ	Aero panel or body which is to be interpolated (Integer > 0).
ID1, ID2	First and last box or body element whose motions are interpolated using this spline (Integer > 0).
SETG	Refers to a SETi card which lists the structural "g"-set to which the spline is attached (Integer > 0).
DZ	Linear attachment flexibility (Real ≥ 0).
DTØR	Torsional flexibility (EI/GJ) (Real > 0; use 1.0 for bodies).
CID	Rectangular coordinate system which defines y-axis of spline (Integer ≥ 0) (not used for bodies, CAERØ2).
DTHX, DTHY	Rotational attachment flexibility. DTHX is for rotation about the x-axis; not used for bodies. DTHY is for rotation about the y-axis; used for slope of bodies (Real).

Remarks:

1. The interpolated points (k-set) will be defined by aero boxes.
2. For panels, the spline axis is the projection of the y-axis of coordinate system CID, projected onto the plane of the panel. For bodies, the spline axis is parallel to the x-axis of the aerodynamic coordinate system.
3. The flexibilities are used for smoothing. Zero attachment flexibility values will imply rigid attachment, i.e., no smoothing. (Negative values in fields 12 and 13 will imply infinity, hence no attachment.)
4. A continuation card is required.
5. The SPLINE2 EID must be unique with respect to all SPLINEi data cards.

Input Data Card SPLINE3

Description: Defines a constraint equation for aeroelastic problems. Useful for control surface constraints.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPLINE3	EID	CAERØ	UKID	CØMP	G1	C1	A1		ABC
SPLINE3	7000	107	109	6	33	5	1.0		abc
+BC	G2	C2	A2		G3	C3	A3		
+bc	43	5	-3.0						

Field — Contents

EID — Element identification number (Integer > 0).

CAERØ — Identification number of macro-element on which the element to be interpolated lies (Integer > 0).

UKID — Identification number of the u_k point (i.e., the box number)(Integer > 0).

CØMP — The component of motion to be interpolated. 3 = normal rotation, 5 = pitch angle (for z, yz bodies), 6 = control relative angle (also for y-bodies 2 = lateral displacement and 6 = yaw). (Integer > 0)

Gi — Grid point identification number of independent grid point (Integer > 0).

Ci — Component (in global coordinate system) to be used (one of the Integers 1 thru 6, or 0 for scalar points).

Ai — Coefficient of constraint relationship (Real).

Remarks:

1. The independent grid points and components must refer to degrees of freedom in the u_g point set.
2. The constraint is given by

$$u_d = \sum_i A_i u_i$$

u_d = the value of the dependent u_k component.

u_i = the displacement at grid Gi, component Ci.

3. The SPLINE3 EID must be unique with respect to all SPLINEi data cards.

Input Data Card TABDMP1 Structural Damping Table

Description: Defines structural damping as a tabular function of frequency.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABDMP1	ID								abc
TABDMP1	3								ABC
+bc	F_1	G_1	F_2	G_2	F_3	G_3	F_4	G_4	
+BC	2.5	.01057	2.6	.01362	ENDT				

Field	Contents
ID	Table identification number (Integer > 0)
F_i	Frequency value in cycles per unit time (Real $\geq$ 0.0)
G_i	Damping value (Real)

Remarks:

1. The F_i must be in either ascending or descending order but not both.
2. Jumps ($F_i = F_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. Any F_i, G_i entry may be ignored by placing the BCD string "SKIP" in either of two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. The TABDMP1 mnemonic infers the use of the algorithm

$$\boxed{G = g_T(F)}$$

where F is input to the table and G is returned. The table look-up $g_T(F)$ is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $g_T(F)$ is used. There are no error returns from this table look-up procedure.

7. Structural damping tables must be selected in the Case Control Deck (SDAMP=ID) to be used by NASTRAN.
8. Structural damping is used only in modal formulations of complex eigenvalue analysis, frequency response analysis, or transient response analysis.
9. A PARAM, KDAMP, is used in Aeroelastic rigid formats to select the type of damping. See PARAM bulk data card.

Input Data Card TABLED1 Dynamic Load Tabular Function

Description: Defines a tabular function for use in generating frequency-dependent and time-dependent dynamic loads.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLED1	ID								+abc
TABLED1	32								ABC
+abc	X_1	Y_1	X_2	Y_2	X_3	Y_3	X_4	Y_4	
+BC	-3.0	6.9	2.0	5.6	3.0	5.6	ENDT		

Field	Contents
ID	Table identification number (Integer > 0)
X_i, Y_i	Tabular entries (Real)

Remarks:

1. The X_i must be in either ascending or decending order but not both.
2. Jumps between two points ($X_i = X_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. Any X-Y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. Each TABLEDi mnemonic infers the use of a specific algorithm. For TABLED1 type tables, this algorithm is

$$\boxed{Y = y_T(X)}$$

where X is input to the table and Y is returned. The table look-up $y_T(x)$, $x = X$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

7. Linear extrapolation is not used for Fourier Transform methods. The function is zero outside the range.

Input Data Card TABLED2 Dynamic Load Tabular Function

Description: Defines a tabular function for use in generating frequency-dependent and time-dependent dynamic loads. Also contains parametric data for use with the table.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLED2	ID	X1							+abc
TABLED2	15	-10.5							ABC
+abc	X_1	Y_1	X_2	Y_2	X_3	Y_3	X_4	Y_4	+def
+BC	1.0	-4.5	2.0	-4.2	2.0	2.8	7.0	6.5	DEF
+def	X_5	Y_5	X_6	Y_6	X_7	Y_7	X_8	Y_8	
+EF	SKIP	SKIP	9.0	6.5	ENDT				

Field	Contents
ID	Table identification number (Integer > 0)
X1	Table parameter (Real)
X_i, Y_i	Tabular entries (Real)

Remarks:

1. The X_i must be in either ascending or descending order but not both.
2. Jumps between two points ($X_i = X_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. Any X-Y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. Each TABLEDi mnemonic infers the use of a specific algorithm. For TABLED2 type tables, this algorithm is

$$\boxed{Y = y_T(X - X1)}$$

where X is input to the table and Y is returned. The table look-up $y_T(x)$, $x = X-X1$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

7. Linear extrapolation is not used for Fourier Transform methods. The function is zero outside the range.

Input Data Card TABLED3 Dynamic Load Tabular Function

Description: Defines a tabular function for use in generating frequency-dependent and time-dependent dynamic loads. Also contains parametric data for use with the table.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLED3	ID	X1	X2						+abc
TABLED3	62	126.9	30.0						ABC
+abc	X_1	Y_1	X_2	Y_2	X_3	Y_3	X_4	Y_4	
+BC	2.9	2.9	3.6	4.7	5.2	5.7	ENDT		

Field	Contents
ID	Table identification number (Integer > 0)
X1, X2	Table parameters (Real; X2 ≠ 0.0)
X_i, Y_i	Tabular entries (Real)

Remarks:

1. The X_i must be in either ascending or descending order but not both.
2. Jumps between two points ($X_i = X_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. Any X-Y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. Each TABLEDi mnemonic infers the use of a specific algorithm. For TABLED3 type tables, this algorithm is

$$Y = y_T\left(\frac{X - X1}{X2}\right)$$

where X is input to the table and Y is returned. The table look-up $y_T(x)$, $x = \frac{X - X1}{X2}$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

7. Linear extrapolation is not used for Fourier Transform methods. The function is zero outside the range.

Input Data Card TABRNDG Gust Power Spectral Density

Description: Defines the power spectral density of a gust for Aeroelastic analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABRNDG	ID	TYPE	LU	WG					
TABRNDG	1020	1	1.3	1.					

Field	Contents
ID	Table identification number (Integer > 0).
TYPE	Choice of Von Kármán (TYPE=1) or Dryden model (TYPE=2) (Integer 1 or 2).
LU	L/U, scale of turbulence divided by velocity (units of time) (Real).
WG	Root-mean-square gust velocity.

Remarks:

1. This card must be referenced on a RANDPS data card.
2. The power spectral density is given by:

$$S_q(\omega) = 2(WG)^2(L/U)\frac{1+2(p+1)k^2(L/U)^2\omega^2}{[1+k^2(L/U)^2\omega^2]^{p+3/2}}$$

where

Type	p	k
1=Von Karman	1/3	1.339
2=Dryden	1/2	1.0

and $\omega = 2\pi f$. The units of $S_q(\omega)$ are velocity squared per Hertz.

3. Other PSD functions may be defined using the TABRND1 data card.

Input Data Card TICS Transient Initial Condition - Substructure Analysis

Description: Defines values for the initial conditions of coordinates used in Direct Transient analysis. Both displacement and velocity values may be specified at independent coordinates of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TICS	SID	NAME	G	C	UO	VO			
TICS	1	SPAR	3	2	5.0	-6.0			

Field	Contents
SID	Set identification number (Integer > 0)
NAME	Basic substructure name
G	Grid or scalar or extra point identification number (Integer > 0)
C	Component number (Null or zero for scalar or extra points, any one of the digits 1-6 for a grid point)
UO	Initial displacement value (Real)
VO	Initial velocity value (Real)

Remarks:
1. Transient initial condition sets must be selected in the Case Control Deck (IC=SID) to be used by NASTRAN.
2. If no TIC set is selected in Case Control Deck, all initial conditions are assumed zero.
3. Initial conditions for coordinates not specified on TIC cards will be assumed zero.
4. Initial conditions may be used only in direct formulation (Rigid Format 9) and may only be applied to the analysis degrees of freedom, i.e., only those coordinates retained in the solution substructure and not constrained using MPC, SPC, or ØMIT data.
5. Used in substructure SØLVE operation.

Input Data Card TLØAD1 Transient Response Dynamic Load

Description: Defines a time-dependent dynamic load of the form

$$\{P(t)\} = \{A\ F(t - \tau)\}$$

for use in transient response problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TLØAD1	SID	L	M		TF				
TLØAD1	5	7	9		13				

Field	Contents
SID	Set identification number (Integer > 0)
L	Identification number of DAREA card set or a thermal load set which defines A (Integer > 0). For automated multi-stage substructuring, reference a DAREAS card set. If desired, the set identification may also reference LØADC cards.
M	Identification number of DELAY or DELAYS card set which defines τ (Integer $\geq$ 0)
TF	Identification number of TABLEDi card which gives $F(t - \tau)$ (Integer > 0)

Remarks:

1. If M is zero, τ will be zero.
2. Field 5 must be blank.
3. Dynamic load sets must be selected in the Case Control Deck (DLØAD=SID) to be used by NASTRAN.
4. TLØAD1 loads may be combined with TLØAD2 loads only by specification on a DLØAD card. That is, the SID on a TLØAD1 card may not be the same as that on a TLØAD2 card.
5. SID must be unique for all TLØAD1, TLØAD2, RLØAD1 and RLØAD2 cards.
6. Field 3 may reference sets containing QHBDY, QBDY1, QBDY2, QVECT, and QVØL cards when using the heat transfer option.
7. If the heat transfer option is used, the referenced QVECT data card may also contain references to functions of time, and therefore A may be a function of time.
8. Fourier analysis will be used if this is selected in an Aeroelastic Response Problem.
9. With automated multi-stage substructuring, DAREAS cards may only reference degrees of freedom in the boundary set of the solution structure.
10. When L references LØADC cards, DAREAS cards with the same set identification and non-zero loads must also exist.

Input Data Card TLØAD2 Transient Response Dynamic Load

Description: Defines a time-dependent dynamic load of the form

$$\{P(t)\} = \begin{cases} \{0\}, & \tilde{t} < 0 \text{ or } \tilde{t} > T2 - T1 \\ \left\{A\, \tilde{t}^{B}\, e^{C\tilde{t}} \cos(2\pi F\tilde{t} + P)\right\}, & 0 \le \tilde{t} \le T2 - T1 \end{cases}$$

for use in transient response problems where $\tilde{t} = t - T1 - \tau$.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TLØAD2	SID	L	M		T1	T2	F	P	abc
TLØAD2	4	10	7		2.1	4.7	12.0	30.0	+12
+bc	C	B							
+12	2.0	3.0							

Field	Contents
SID	Set identification number (Integer > 0)
L	Identification number of DAREA card set or a thermal load set which defines A (Integer > 0). For automated multi-stage substructuring, reference a DAREAS card set. If desired, the set identification may also reference LØADC cards.
M	Identification number of DELAY or DELAYS card set which defines τ (Integer $\geq$ 0)
T1	Time constant (Real $\geq$ 0.0)
T2	Time constant (Real, T2 > T1)
F	Frequency in cycles per unit time (Real $\geq$ 0.0)
P	Phase angle in degrees (Real)
C	Exponential coefficient (Real)
B	Growth coefficient (Real)

Remarks:

1. If M is zero, τ will be zero.
2. Field 5 must be blank.
3. Dynamic load sets must be selected in the Case Control Deck (DLØAD=SID) to be used by NASTRAN.
4. TLØAD2 loads may be combined with TLØAD1 loads only by specification on a DLØAD card. That is, the SID on a TLØAD2 card may not be the same as that on a TLØAD1 card.
5. SID must be unique for all TLØAD1, TLØAD2, RLØAD1 and RLØAD2 cards.

TLØAD2 (Cont.)

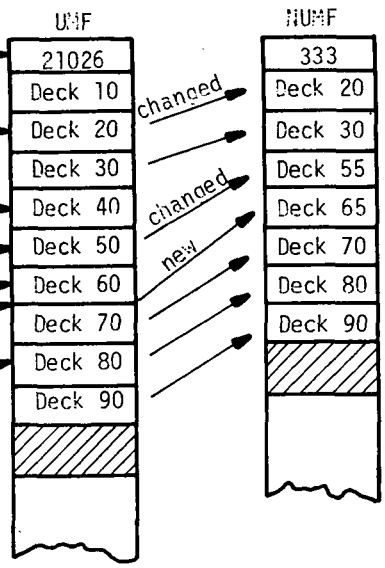
6. Field 3 may reference load sets containing QHBDY, QBDY1, QBDY2, QVECT, QVØL and SLØAD cards when using the heat transfer option.

7. If the heat transfer option is being used, the referenced QVECT load card may also contain references to functions of time, and therefore A may be a function of time.

8. Fourier analysis will be used if this selection is an Aeroelastic Response problem.

Example 4. Edit a User's Master File

```
ID A,B
TIME 5
APP DMAP
BEGIN
END
UMF  21026, 20
UMFEDIT
CEND
TITLE = MØDIFICATIØN ØF
SUBTITLE = DECKS 20 AND 50
ECHØ = BØTH
BEGIN BULK
  {alter cards for Deck 20}
ENDDATA
NUMF  333, 20
REMØVE 40
UMF  21026, 50
BEGIN BULK
  {alter cards for Deck 50}
ENDDATA
NUMF  333, 55
REMØVE 60
UMF  21026, 0
BEGIN BULK
  {Deck 65}
ENDDATA
NUMF 333, 65
LIST 80
FINIS
```



Notes:

1. A tape containing the User's Master File to be edited must be set up on NASTRAN file UMF.
2. A tape must be set up on NASTRAN file NUMF.
3. The DMAP sequence is not used but must appear in the Executive Control Deck.
4. ECHØ = BØTH is recommended since the alter cards are available only during the run used to perform the edit. The sorted echo is needed for those decks being altered in order to make further alterations to the bulk data when using the newly created User's Master File in a NASTRAN run. Decks not being altered will not be echoed as a result of the ECHØ = BØTH card. Such decks may be echoed as they are copied as shown in the example for Deck 80.
5. The pid values must form an increasing sequence.
6. The requests in the above example will cause listings to be generated for deck 80; no decks will be punched.
7. Decks 30, 70, 80, and 90 will be copied onto the NUMF with no changes.
8. Decks 10, 40, and 60 will be removed (i.e., not copied onto the NUMF).
9. Decks 20 and 50 will be modified. In addition the problem identification number of Deck 50 will be changed to 55.
10. Deck 65 will be added.
11. Deck 10 is removed because it appears prior to the first call to the Editor. This may be avoided by using a pid of zero and a dummy Bulk Data Deck as shown in Example 3.

Table 1. User's Master File Editor Control Card Actions.

I. UMF Only is Present

A. FINIS
 1. Terminate run.
B. BEGIN BULK (Not Allowed)
C. REMØVE pid (Not Allowed)
D. LIST pid
 1. Skip UMF forward to pid and list the Bulk Data Deck on the printer.
E. PUNCH pid
 1. Skip UMF forward to pid and punch the Bulk Data Deck on the punch.
F. UMF tid, pid (Not Allowed)
G. NUMF tid, pid (Not Allowed)
H. PUNPRT pid
 1. Skip UMF forward to pid and then list and punch the Bulk Data Deck.
I. PRINT tid
 1. List all Bulk Data Decks and Summary Table of Contents.
J. TØC tid
 1. List all Bulk Data Decks Summary Table of Contents.

II. NUMF Only is Present

A. FINIS
 1. Write end-of-file on NUMF.
 2. Terminate run.
B. BEGIN BULK
 1. Process the next Bulk Data Deck.
C. REMØVE pid (Not Allowed)
D. LIST pid (Not Allowed)
E. PUNCH pid (Not Allowed)
F. UMF tid, pid (Not allowed)
G. NUMF tid, pid
 1. If first entry to Editor, write tape identification file on NUMF.
 2. Add preceding Bulk Data to NUMF and automatically punch and list the UMF card for use with UMF.
H. PUNPRT pid (Not Allowed)
I. TØC tid (Not Allowed)
J. PRINT tid (Not Allowed)

III. Both UMF and NUMF are Present

A. FINIS
 1. Copy any remaining Bulk Data Decks from UMF to NUMF.
 2. Write end-of-file on NUMF.
 3. Terminate run.
B. BEGIN BULK
 1. Process the next Bulk Data Deck which may be a new deck or a modified deck from the UMF.
C. REMØVE pid
 1. Copy UMF onto NUMF up to indicated deck.
 2. Skip indicated deck on UMF.
D. LIST pid
 1. Copy UMF onto NUMF through indicated deck.
 2. List indicated Bulk Data Deck on printer.
E. PUNCH pid
 1. Copy UMF onto NUMF through indicated deck.
 2. Punch indicated Bulk Data Deck on printer.
F. UMF tid, pid
 1. Copy UMF onto NUMF up to indicated deck. (Must be immediately followed by BEGIN BULK card.)
G. NUMF tid, pid
 1. If first entry to Editor, write tape identification file on NUMF.
 2. Copy UMF onto NUMF up to deck with identification greater than pid.

Table 1. User's Master File Editor Control Card Actions. (Continued)

G. 3. Add preceding Bulk Data Deck to NUMF and automatically punch and list the UMF card for use with UMF.

H. PUNPRT pid
 1. Copy UMF onto NUMF through indicated deck.
 2. List indicated Bulk Data Deck on printer.
 3. Punch indicated Bulk Data Deck on punch.

I. TØC tid (Not Allowed)

J. PRINT tid (Not Allowed)

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY.

Table 2. Summary of User's Master File Editor Control Cards.

LIST pid	List the problem deck from UMF or copy the problem deck from UMF onto NUMF and list it.
NUMF tid, pid	Add problem deck to NUMF, list it and punch UMF card.
PRINT tid	List all problem decks from UMF and Summary Table of Contents.
PUNCH pid	Punch the problem deck from UMF or copy the problem deck from UMF onto NUMF and punch it.
PUNPRT pid	Punch and print the problem deck from UMF or copy the problem deck from UMF onto NUMF and punch and print it.
REMØVE pid	Copy problem decks from UMF onto NUMF up to pid and skip over problem pid.
TØC tid	List all problem decks (Summary Table of Contents) by UMF number from UMF.
UMF tid, pid	Copy UMF problem deck onto NUMF, list it and punch UMF card.

2.5.5 NASTRAN Demonstration Problems

The standard set of NASTRAN Demonstration Problems are each identified by a UMF tid, pid card. Thus, to run a demonstration problem, either use the Executive and Case Control driver decks provided or alter them and then add the bulk data deck from the UMF. Bulk data cards can be deleted with the / card or others can be added by referring to the sorted Bulk Data Deck Card number. See the NASTRAN Demonstration Problems Manual for the appropriate UMF number.

2.7 SUBSTRUCTURE CONTROL DECK

The Substructure Control Deck options provide the user commands needed to control the execution of NASTRAN for automated multi-stage substructure analyses. These commands are input on cards with the same format conventions as are used for the normal NASTRAN Case Control Deck.

Initiation of a substructure analysis is achieved via the Executive Control Deck command (see Section 2.1):

APP DISPLACEMENT,SUBS

This command directs NASTRAN to automatically generate the required DMAP sequence of alters to the specified Rigid Format necessary to perform the operations requested in the Substructure Control Deck. Following the Substructure Control Deck in the NASTRAN input data stream comes the standard Case Control Deck which specifies the loading conditions, omit sets, method of eigenvalue extraction, element sets for plotting, plot control, and output requests, etc.

The Substructure Control Deck commands are summarized in Table 1 where they are listed under one of three categories according to whether they:

1. Specify the phase and mode of execution
2. Specify the substructuring matrix operations
3. Define and control the substructure operating file (SØF)

Several commands have associated with them a set of subcommands used to specify additional control information appropriate to the processing requested by the primary command. These subcommands are defined together with the alphabetically sorted descriptions of their primary commands in Section 2.7.3. Examples utilizing these commands are presented in Section 1.

The sections that follow discuss the interaction between the substructure commands and the standard case control commands, the translation of substructure commands into DMAP ALTER sequences, and the format conventions to be used. The bulk data cards provided for substructure analyses are included with the standard bulk data descriptions in Section 2.3 and they are summarized for convenient reference in Table 2.

Table 1. Summary of Substructure Commands

A. Phase and Mode Control	
#SUBSTRUCTURE	- Defines execution phase (1, 2, or 3) (Required)
NAME*	- Specifies Phase 1 substructure name
SAVEPLØT	- Requests plot data be saved in Phase 1
ØPTIØNS	- Defines matrix options (K, B, K4, M, P, or PA)
RUN	- Limits mode of execution (DRY, GØ, DRYGØ, STEP)
#ENDSUBS	- Terminates Substructure Control Deck (Required)
B. SØF Controls	
#SØF	- Assigns physical files for storage of the SØF (Required)
PASSWØRD*	- Protects and ensures access to correct file
SØFØUT or SØFIN	- Copies SØF data to or from an external file
PØSITIØN	- Specifies initial position of input file
NAMES	- Specifies substructure name used for input
ITEMS	- Specifies data items to be copies in or out
SØFPRINT	- Prints selected items from the SØF
DUMP	- Dumps entire SØF to a backup file
RESTØRE	- Restores entire SØF from a previous DUMP operation
CHECK	- Checks contents of external file created by SØFØUT
DELETE	- Edits out selected groups of items from the SØF
EDIT	- Edits out selected groups of items from the SØF
DESTRØY	- Destroys all data for a named substructure and all the substructures of which it is a component
C. Substructure Operations	
CØMBINE	- Combines sets of substructures
NAME*	- Names the resulting substructure
TØLERANCE*	- Limits distance between automatically connected grids
CØNNECT	- Defines sets for manually connected grids and releases
ØUTPUT	- Specifies optional output results
CØMPØNENT	- Identifies component substructure for special processing
TRANSFØRM	- Defines transformations for named compoennt substurctures
SYMTRANSFØRM	- Specifies symmetry transformation
SEARCH	- Limits search for automatic connects
EQUIV	- Creates a new equivalent substructure
PREFIX*	- Prefix to rename equivalenced lower level substructures

Mandatory Control Cards * Required Subcommand

Table 1. Summary of Substructure Commands (continued)

C. Substructure Operations (continued)	
REDUCE	- Reduces substructure matrices
NAME*	- Names the resulting substructure
BØUNDARY*	- Defines set of retained degrees of freedom
ØUTPUT	- Specifies optional output requests
RSAVE	- Save REDUCE decomposition product
MREDUCE	- Reduces substructure matrices
NAME*	- Names the resulting substructure
BØUNDARY*	- Defines set of retained degrees of freedom
FIXED	- Defines set of constrained degrees of freedom for modes calculation
RNAME	- Specifies basic substructure to define reference point for inertia relief shapes
RGRID	- Specifies grid point in the basic substructure to define reference point for inertia relief shapes. Defaults to origin of basic substructure coordinate system
METHØD	- Identifies EIGR Bulk Data card
RANGE	- Identifies frequency range for retained modal coordinates
NMAX	- Identifies number of lowest frequency modes for retained modal coordinates
ØLDMØDES	- Flag to identify rerunning problem with previously computed modal data
ØLDBØUND	- Flag to identify rerunning problem with previously defined boundary set
USERMØDES	- Flag to indicate modal data have been input on bulk data
ØUTPUT	- Specifies optional output requests
RSAVE	- Indicates the decomposition product of the interior point stiffness matrix is to be sotred on the SØF
CREDUCE	- Reduces substructure matrices using a complex modes transformation
NAME*	- Names the resulting substructure
BØUNDARY	- Defines set of retained degrees of freedom
FIXED	- Defines set of constrained degrees of freedom for modes calculation
METHØD	- Identifies EIGC Bulk Data card
RANGE	- Identifies frequency range of imaginary part of the root for retained modal coordinates
NMAX	- Identifies number of lowest frequency modes for retained modal coordinates
ØLDMØDES	- Flag to identify rerunning problem with previously computed modal data
RSAVE	- Indicates the decomposition product of the interior point stiffness matrix is to be stored on the SØF
MRECØVER	- Recovers mode shape data from an MREDUCE or CREDUCE operation
SAVE	- Stores modal data on SØF
PRINT	- Stores modal data and prints data requested
SØLVE	- Initiates substructure solution (statics, normal modes, frequency response or transient analysis)

* Required Subcommand

Table 1. Summary of Substructure Commands (continued).

C. Substructure Operations (continued)	
RECØVER	- Recovers Phase 2 solution data
SAVE	- Stores solution data on SØF
PRINT	- Stores solution and prints data requested
DISP	- Displacement output request
SPCF	- Reaction force output request
ØLØAD	- Applied load output request
VELØ	- Velocity output requests
ACCE	- Acceleration output requests
BASIC	- Basic substructure for output requests
SØRT	- Output sort order
SUBCASES	- Subcase output request
MØDES	- Modes output request
RANGE	- Mode range output request
ENERGY	- Modal energies output requests
UIMPROVE	- Improved displacement request
STEPS	- Frequency or time step output request
BRECØVER	- Basic Substructure data recovery, Phase 3
PLØT	- Initiates substructure undeformed plots

* Required Subcommand

Table 2. Substructure Bulk Data Card Summary.

A. Bulk Data Used for Processing Substructure Commands REDUCE, MREDUCE, and CREDUCE

BDYC	- Combination of substructure boundary sets of retained degrees of freedom or fixed degrees of freedom for modes calculation
BDYS	- Boundary set definition
BDYS1	- Alternate boundary set definition

B. Bulk Data Used for Processing Substructure Command CØMBINE

CØNCT	- Specifies grid points and degrees of freedom for manually specified connectivities - will be overridden by RELES data
CØNCT1	- Alternate specification of connectivities
RELES	- Specifies grid point degrees of freedom to be disconnected - overrides CØNCT and automatic connectivities
GTRAN	- Redefines the output coordinate system grid point displacement sets
TRANS	- Specifies coordinate systems for substructure and grid point transformations

C. Bulk Data used for Processing Substructure Command SØLVE

LØADC	- Defines loading conditions for static analysis
MPCS	- Specifies multipoint constraints
SPCS	- Specifies single point constraints
SPCS1	- Alternate specification of single point constraints
SPCSD	- Specifies enforced displacements for single point constraints
DAREAS	- Defines dynamic load scale factors
DELAYS	- Defines dynamic load time delays
DPHASES	- Defines dynamic load Phase leads
TICS	- Defines transient initial conditions

2.7.1 Commands and Their Execution

The sequence of operations is controlled by the order in which NASTRAN encounters the substructure commands. A few special data cards are required in any Substructure Command Deck. These are:

SUBSTRUCTURE { PHASE1 / PHASE2 / PHASE3 } - The first card of the Substructure Command Deck and it follows the CEND card of the Executive Control Deck.

SØF / PASSWØRD - Required to define the substructure operating file to be used for this execution.

ENDSUBS - Signals the end of the Substructure Command Deck.

The first step of any substructuring analysis is to define the basic substructures to be used. These are prepared by executing one Phase 1 run for each substructure. Checkpoints may be taken for each Phase 1 execution to save the files to be used during the Phase 3 data recovery runs. Alternately, the user may resubmit his entire original data deck for a Phase 3 run, thereby avoiding a proliferation of checkpoint tapes. During a Phase 2 execution, a long list of instructions may be specified. This list may be split up and run in several separate smaller steps. No checkpointing is required during a Phase 2 run in that all pertinent substructure data will be retained on the substructure operating file (SØF).

The Case Control Deck submitted following the ENDSUBS card will be used to direct the processing appropriate to the particular Phase being executed. During a Phase 1 run, the Case Control will be used to define the loading conditions, single and multipoint constraints (only one set may be used per basic substructure), omits, and desired plot sets. During a Phase 2 run, the Case Control will be used to specify the loads and constraint data for the SØLVE operation, outputting of results, or any plot requests. Finally, for a Phase 3 execution, the Case Control Deck is used to define the detail output and plot requests for each basic substructure.

Normal substructuring analyses will require many steps to be executed under Phase 2 processing. They may all be submitted for processing at once, or they may be divided into several shorter sequences and executed separately. In the event of an abnormal termination, several steps may have been successfully executed. To recover requires simply removing those completed steps from the Substructure Control Deck and resubmitting the remaining commands. The SØF will act as the checkpoint/restart file independently of the normal NASTRAN checkpointing procedures.

If the solution structure is large, a NASTRAN checkpoint would be recommended to save intermediate results during the SØLVE operation. If this is done, however, care must be exercised on restart to insure correct re-entry into the DMAP sequence. This may be accomplished by removing all substructure control commands preceding the SØLVE, modifying the Case Control Deck and Bulk Data Deck to change set identifiers only if any new loads or constraint sets are to be specified and resubmitting the job. If no changes are to be made which would affect the SØLVE operations, a regular restart can be executed without changing the original Case Control and Bulk Data Decks.

The user may wish to add to or modify the DMAP sequence generated automatically from the Substructure Control Deck commands. This user interaction with the DMAP operations is explained in the following section.

2.7.2 Interface with NASTRAN DMAP

Each substructure command card produces a set of DMAP ALTER cards which are automatically inserted into the Rigid Format called for execution on the SØL card of the Execution Control Deck (Section 2.1). These automatically generated alters require no user interfacing unless the user wishes to exercise the following options:

1. The user may insert ALTER cards in the Executive Control Deck. However, they may not overlap any DMAP cards affected by the substructure ALTERs. The DMAP card numbers, modified for each Rigid Format, are given in Sections 3.2, 3.3, and 3.4.

2. The user may suppress the DMAP generated by the substructure deck and run with either ALTER cards or with approach DMAP. To suppress the automatic DMAP, the following forms of the executive control card APP are provided

 APP DISP,SUBS,1 (Retains execution of the substructuring preface operations)

 or APP DMAP (Standard NASTRAN is executed)

3. For user information and convenience, the substructure ALTER packages may be printed and/or punched on cards. The executive control card, DIAG 23, will produce the printout. DIAG 24 will produce the punched deck. The punched deck may then be altered by the user and resubmitted as described in (2) above. However, the order of the associated substructure command deck must not be changed to insure proper sequencing of the requested operations.

2.7.3 Substructure Control Card Descriptions

The format of the substructure control cards is free-field. In presenting general formats for each card embodying all options, the following conventions are used:

1. Upper-case letters must be punched as shown.
2. Lower-case letters indicate that a substitution must be made.
3. Braces { } indicate that a choice of contents is mandatory.
4. Brackets [] contain an option that may be omitted or included by the user.
5. Underlined options or values are the default values.
6. Physical card consists of information punched in columns 1 thru 72 of a card. All Substructure Control Cards are limited to a single physical card.

The Case Control Deck, which follows the ENDSUBS card of the Substructure Control Deck is described in Section 2.3.

2.7.4 SØF Compatibility

The modal synthesis additions to NASTRAN substructuring require changes to the SØF format used with Rigid Format Series N and Ø substructuring. Thus, restrictions apply to the use of Rigid Format Series N and Ø SØFs on later NASTRAN releases. These restrictions are described below. A method for converting a Rigid Format Series N and Ø SØF to the new format, so that no restrictions apply, is also described.

All Rigid Format Series N and Ø substructure operations may be performed using later NASTRAN releases. However, the commands listed below may not be used.

ØPTIØNS B, K4
MREDUCE
CREDUCE
MRECØVER
ENERGY (RECØVER subcommand)
UIMPRØVE (RECØVER subcommand)
SØLVE (Rigid Formats 8 and 9)

Rigid Format Series N and Ø SØFs created with the SØFØUT (EXTERNAL) command may not be used with later NASTRAN releases. The SØF tape should be restructured to INTERNAL format using Rigid Format Series N and Ø and then the SØF can be converted to modal synthesis format using the procedure described below.

The user can convert a Rigid Format Series N and Ø format SØF to compatible formats for later releases of NASTRAN by using the following procedure.

Run 1 (Rigid Format Series N and Ø)

```
SØF(1) = xxxx, xxxx, ØLD
PASSWØRD = xxxx
SØFØUT (INTERNAL) INPT
  PØSITIØN = REWIND
  NAMES = WHØLESØF
  ITEMS = ALL
ENDSUBS
```

Run 2 (Rigid Format Series P)

```
SØF(1) = xxxx, xxxx, NEW
PASSWØRD = xxxx
SØFIN (INTERNAL) INPT
  PØSITIØN = REWIND
  NAMES = WHØLESØF
  ITEMS = ALL
ENDSUBS
```

There are no restrictions on the use of the converted SØF with the later release of NASTRAN. Note, however, that there is no downward conversion capability. For example, a Rigid Format Series Series P SØF may not be used or converted to a Rigid Format Series N and Ø SØF.

The user is also advised that the substructure type or substructure item word sizes are not always identified correctly for Rigid Format Series N and Ø substructures when listed using the Rigid Format Series P SØFPRINT TØC command. This in no way reflects on the actual type and size of these items.

7. The following output requests are available for the CØMBINE operation (* marks recommended output options):

CODE	OUTPUT
2*	SØF table of contents
3	CØNCT1 bulk data summary
4	CØNCT bulk data summary
6	GTRAN bulk data summary
7*	TRANS bulk data summary
9	RELES bulk data summary
11	Summary of automatically-generated connections (in terms of internal point numbers)
12*	Complete connectivity map of final combined pseudostructure defining each internal point in terms of the grid point ID and component substructure it represents
13	The EQSS item
14	The BGSS item
15	The CSTM item
16	The PLTS item
17	The LØDS item

Output printed is formatted SØF data for the newly created pseudostructure (See Section 1.10.2 for definitions).

Examples:

1. CØMBINE PANEL SPAR

```
TØLE = .0001
NAME = SECTA
```

2. CØMBINE (AUTØ,Z) TANK1, TANK2, BULKHD

```
NAME = TANKS
TØLE = .01
CØMPØNENT TANK1
TRAN = 4
SEARCH = BULKHD
CØMPØNENT TANK2
SEARCH = BULKHD
```

3. CØMBINE (MAN) LWING, RWING

```
TØLE = 1.0
NAME = WING
CØMPØNENT LWING
SYMT = Y
```

Substructure Command CREDUCE - Reduces Substructure Matrices Using Complex Modes

Purpose: This operation performs a complex modal synthesis reduction on a specified component substructure. The resulting substructure will be defined by boundary point displacements and modal displacements as degrees of freedom. The operation is allowed in both Phase 1 and Phase 2 jobs and may be performed at any level of the substructure process.

Request Format:

CREDUCE name

Subcommands:

NAME - new name

BØUNDARY - b

FIXED - f

METHØD - k

RANGE - f_1, f_2

NMAX - N

ØUTPUT - m_1, m_2

ØLDMØDES - m

GPARAM - g

RSAVE

Definitions:

name - Name of substructure to be reduced

new name - Name of resulting substructure

b - Set identification number of BDYC Bulk Data cards which define sets of boundary degrees of freedom (Integer > 0)

f - Optionally identifies BDYC data defining degrees of freedom temporarily fixed during mode extraction (Integer $\geq$ 0, Default = 0)

k - Identifies EIGC Bulk Data card for control of the eigenvalue extraction (Integer > 0)

f_1, f_2 - Optional frequency range (H_Z) for the imaginary part of the root defining eigenvectors to be used in the mode synthesis formulation (Real, Default = ALL)

NMAX - Optional number of lowest modes, measured by magnitude of eigenvalue, within frequency range to be used in mode synthesis formulation (Integer, Default = ALL)

m_1, m_2 - Optional output requests (see Note 2)

m - Flag for rerunning problem with old eigenvectors (YES or NØ)

g - Structure damping parameter (real)

Notes: 1. All references to the grid points and components not defined in the "boundary set" will be reduced out of the new substructure. Any subsequent reference to these omitted degrees of freedom in CØMBINE, CREDUCE, MREDUCE, REDUCE, or SØLVE operations generates an error condition.

2. The following output requests are available for the CREDUCE operation (* marks recommended output options):

Code	Output	
1*	Current problem summary	
2	Boundary set summary	
3	Summary of grid point ID numbers in each boundary set	
4	The EQSS item for the structure being reduced	
5*	The EQSS item	These requests write formatted SØF items for the new reduced pseudostructure
6*	The BGSS item	
7	The CSTM item	
8	The PLTS item	
9*	The LØDS	
10*	Modal dof set summary	
11	Fixed set summary	
12	Summary of grid point ID numbers in each fixed set	

3. The ØLDMØDES option instructs the program to use the existing modal data but create new boundary matrices for a new boundary set. To exercise the ØLDMØDES option, the user must use the following sequence of commands to eliminate previously calculated boundary point data:

```
EDIT(32) new name (previous modal reduction name)

DELETE name, GIMS, LMTX, HLFT, HØRG, UPRT

DELETE name, PØVE, PØAP

CREDUCE name
   .
   .
   .
```

4. If the RSAVE card is included, the decomposition product of the interior point stiffness matrix (LMTX item) is saved on the SØF file. This matrix will be used in the data recovery for the omitted points. If it is not saved it will be regenerated when needed.

Substructure Command DELETE

Purpose: To delete individual substructure items from the SØF.

Request Format:

DELETE name, item1, item2, item3, item4, item5

Subcommands: None

Definitions:

name - Substructure name

item1, item2,... - Item names (HØRG, KMTR, LØDS, SØLN, etc.)

Notes: 1. DELETE may be used to remove from one to five items of any single substructure.

2. For primary substructures, items of related secondary substructures are removed only if the later point to the same data (KMTX, MMTX, etc.).

3. For secondary and image substructures, no action is taken on items of related substructures, i.e., items of equivalenced substructures or higher or lower level substructures.

4. See the EDIT and DESTRØY commands for other means of removing substructure data.

Substructure Command DUMP

Purpose: To copy the entire SØF to an external file.

Request Format:

DUMP filename $\left\{ \begin{matrix} \text{DISK} \\ \text{'TAPE} \end{matrix} \right\}$

Subcommands: None

Definitions:

Filename - Name of the external file. Any one of the following: INPT, INP1,..., INP9.

DISK - File resides on a direct access device.

TAPE - File resides on tape.

Notes:
1. DUMP may be used to create a backup copy of the SØF.
2. All system information on the SØF is saved.
3. The RESTØRE command will reload a DUMPed SØF.
4. DUMP/RESTØRE may not be used to change the size of the SØF.
5. It is more efficient to use operating system utility programs to create back-up copies of the SØF if they are available.

Substructure Command EDIT - Selectively Removes Data from SØF File

Purpose: To permanently remove selected substructure data from the SØF.

Request Format:

EDIT (opt) name

Subcommands: None

Definitions:

name - Name of substructure.

opt - Integer value reflecting combinations of requests. The sum of the following integers defines the combination of data items to be removed from the SØF.

ØPT	Items Removed
1	Stiffness matrix (KMTX)
2	Mass matrix (MMTX)
4	Load data (LØDS, LØAP, PVEC, PAPP)
8	Solution data (UVEC, QVEC, SØLN)
16	Transformation matrices defining next level (HØRG, UPRT, PØVE, PØAP, LMTX, GIMS, HLFT)
32	All items for the substructure
64	Appended loads data (LØAP, PAPP, PØAP)
128	Damping matrices (K4MX, BMTX)
256	Modal reduction data (LAMS, PHIS, PHIL)
512	Total transforms only (HØRG, HLFT)

Notes:
1. The user is cautioned on the removal of the transformation matrix data. These matrices are required for the recovery of the solution results.
2. For primary substructures, items of related secondary substructures are removed only if they point to the same data (KMTX, MMTX, etc.)
3. For secondary and image substructures, no action is taken on items of related substructures, i.e., items of equivalenced or higher or lower level substructures.
4. If the EDIT feature is to be employed, the user should consider also using SØFØUT to ensure the existence of backup data in the event of an error.
5. See DELETE and DESTRØY for other means of removing substructure data.

Substructure Command ENDSUBS - Defines the End of the Substructure Control Deck.

Purpose: This command terminates the processing of automated substructuring controls and directives.

Request Format:

ENDSUBS

Subcommands:

None

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY.

Substructure Command MRECØVER - Eigenvector Recovery for Modal Synthesis Operations

Purpose: This operation recovers modal displacements and boundary forces for substructures reduced to modal coordinates. The results are saved on the SØF file and they may be printed upon user request. This command may be input after the MREDUCE or CREDUCE commands or at a later time as desired.

Request Format:

RECØVER s-name

Subcommands:

SAVE - name

PRINT - name

DISP - { ALL / n / NØNE }

SPCF - { ALL / n / NØNE }

BASIC - b-name

ENERGY - { ALL / n / NØNE }

SØRT - { MØDES / SUBSTRUCTURE }

MODES - { ALL / n / NØNE }

RANGE - f_1, f_2

UIMPRØVE

Definitions:

s-name - Name of the substructure named in a prior MREDUCE or CREDUCE command from which the solution results are to be recovered.

name - Name of the component structure for which results are to be recovered. May be the same as "s-name"

b-name - Name of component basic substructure that following output requests are to apply

ALL - Øutput for all points will be produced.

NØNE - No output is to be produced.

n - Set identification number of a SET card appearing in Case Control. Only output for those points whose identification number appears on this SET card will be produced.

f_1, f_2 - Range of frequencies for which output will be produced. If only f_1 is present the range is assumed to be 0 - f_1.

MØDES - All output requests for each mode will appear together.

SUBSTRUCTURE - All output requests for each basic substructure will appear together.

Output Requests: Printed output produced by the MRECØVER PRINT command can be controlled by requests present in either Case Control or the MRECØVER command in the Substructure Control Deck. If no output requests are present, the PRINT command is equivalent to SAVE and no output will be printed.

The output options described above may appear after any PRINT command. These output requests will then override any Case Control requests. The output requests for any PRINT command can also be specified for any or all basic component substructures of the results being recovered. These requests will then override any requests in Case Control or after the PRINT command.

Example of output control:

```
MRECØVER SØLSTRCT
    PRINT   ABSC
        SØRT = SUBSTRUCTURE  }
        DISP = ALL           }  basic defaults for ABDC output
        BASIC   A            }
            DISP = 5         }  override requests for BASIC A
        BASIC   C            }
            SPCF = 20        }  override requests for BASIC C
    SAVE   ABC
```

Notes:
1. SAVE will save the solution for substructure "name" on the SØF. PRINT will save and print the solution.
2. If the solution data already exists on the SØF, the existing data can be printed without costs of regeneration with the PRINT command.
3. For efficiency, the user should order multiple SAVE and/or PRINT commands so as to trace one branch at a time starting from his solution structure.
4. Reaction forces are computed for a substructure only if (1) the substructure is named on a PRINT subcommand and, (2) an output request for SPCFØRCE or modal energies exists in the Case Control or the RECØVER command.
5. All set definitions should appear in Case Control to ensure their availability to the MRECØVER module.
6. The SØRT output option should only appear after a PRINT command. Any SØRT commands appearing after a BASIC command will be ignored.
7. If both a MØDES request and a RANGE request appear for dynamic analysis, both requests must be satisfied for any output to be produced.
8. The media, print or punch, where output is produced is controlled through Case Control requests. If no Case Control requests are present, the default of print is used.
9. If the UIMPRØVE request is present for a substructure that was input to a REDUCE, MREDUCE, or CREDUCE, an improved displacement vector will be generated. This vector will contain the effects of inertia and damping forces.
10. The ENERGY request will cause the calculation of modal energies on all included and excluded modal dof for a modal reduced substructure. This request should appear for the substructure that was input to the modal reduce operation so that required data needed for the excluded mode calculations exists. This request requires that the UVEC item exists for the next highest level structure.

11. The user can specify print thresholds for all printout. If the absolute value is less than the threshold, the value will be set to zero. The following thresholds can be input on PARAM bulk data cards.

 UTHRESH - displacement, velocity and acceleration threshold

 PTHRESH - load threshold

 QTHRESH - reaction force threshold

Substructure Command MREDUCE - Reduces Substructure Matrices Using Real, Normal Modes

Purpose: This operation performs a modal synthesis reduction on a specified component substructure. The resulting substructure will be defined by boundary coordinate displacements and modal coordinate displacements as degrees of freedom. The operation is allowed in both Phase 1 and Phase 2 jobs and may be performed at any level of the substructure process.

Request Format:

MREDUCE name

Subcommands:

NAME - new name

BØUNDARY - b

FIXED - f

METHØD - k

RANGE - f_1, f_2

NMAX - N

RGRID - i

RNAME - c-name

RSAVE

ØLDMØDES - m

ØLDBØUND - n

USERMØDES - j,

ØUTPUT - m_1, m_2

Definitions:

name - Name of substructure to be reduced

new name - Name of resulting substructure

b - Set identification number of BDYC Bulk Data cards which define sets of boundary degrees of freedom (Integer).

f - Optionally identifies BDYC data defining degrees of freedom temporarily fixed during mode extraction (Integer, Default = 0).

k - Identifies EIGR Bulk Data card for control of the mode extraction (Integer > 0).

i - Grid point number for defining origin of free body motion. Used with RNAME to define substructure component containing grid point i (Integer $\geq$ 0, Default = 0).

c-name - Name of basic substructure which contains grid point i. If RGRID = 0 or is missing, the origin of the overall basic coordinate system is used to define the six rigid body motions. These motions define the inertia relief deflection shapes which are used as generalized coordinates in addition to the modal coordinates.

m - Flag for rerunning problem with old mode shapes (YES or NØ).

n - Flag for rerunning problem with old boundaries for different eigenvalue method (YES or NØ).

f_1, f_2 - Optional frequency range (H_z) defining modes to be used in the mode synthesis formulation (Real, Default = ALL).

NMAX - Optional number of lowest modes within frequency range to be used in mode synthesis formulation (Integer, Default = ALL).

j - Option used in Phase 1 when METHØD data is missing and user-input modes are used directly (see Note 6).

m_1, m_2 - Optional output requests (see Note 3).

Notes:

1. All references to the grid points and components not defined in the "boundary set" will be reduced out of the new substructure. Any subsequent reference to these omitted degrees of freedom in CØMBINE, CREDUCE, MREDUCE, REDUCE, or SØLVE operations generates an error condition.

2. The resulting substructure will be defined in terms of the following degrees of freedom:

 u_b - boundary grid point displacements.

 δ_j - modal displacements relative to static deflection shapes induced by boundary inertia.

 δ_o - Inertia relief generalized coordinates defined by inertia relief deflection shapes occurring from boundary point rigid body accelerations.

 Note that a new substructure will be automatically created to define coordinates δ_o and δ_j. The name will be the same as given by NAME and the point identification numbers are 1-6 for δ_o and 101, 102,... for δ_j.

3. The same transformations applied to the stiffness matrix will be applied to the loads, mass, and damping matrices for the new substructure. See the NASTRAN Theoretical Manual for a discussion of this effect.

4. The following output requests are available for the MREDUCE operation (* marks recommended options):

Code	Output
1*	Current problem summary
2	Boundary set summary
3	Summary of grid point ID numbers in each boundary set
4	The EQSS item for the structure being reduced

Code	Output (continued)	
5*	The EQSS item	These requests write formatted SØF items for the new reduced pseudostructure
6*	The BGSS item	
7	The CSTM item	
8	The PLTS item	
9*	The LØDS item	
10*	Modal dof set summary	
11	Fixed set summary	
12	Summary of grid point ID numbers in each fixed set	

5. The options ØLDMØDES and ØLDBØUND allow the user to rerun the reduction and:

 a. Change the boundary without recalculating modes.

 b. Change the modes without the boundary condensation calculations.

 c. Select a different mode range from the existing vectors and avoid recalculating modes and boundary matrices.

6. The user must provide the actual mode data in Phase 1 when USERMØDES = N is given. Two options are provided:

 a. If N = 1, the structure must be entirely defined by a finite element model and the eigenvectors for the NASTRAN u_a set provided in data block PHIS input using DMI cards.

 b. If N = 2, the entire structure need not be defined. The user provides eigenvectors and forces of constraint only at the selected boundary points as well as eigenvalues and modal masses. Residual stiffness and mass matrices may also be provided to define properties at the boundary points. Use DMI and DTI cards for these data.

7. If the RSAVE card is included, the decomposition product of the interior point stiffness matrix (LMTX item) is saved on the SØF file. This matrix will be used in the data recovery for the omitted points. If it is not saved it will be regenerated when needed.

8. Exercising the ØLDMØDES option, the user must use the following sequence of commands:

 EDIT(32) new name (previous modal reduction name)

 EDIT(16) name

 MREDUCE name

 NAME = new name

9. Exercising the ØLDBØUND option, the user must use the following sequence of commands:

 EDIT(32) new name (previous modal reduction name)

 EDIT(768) name

 MREDUCE name

 NAME = new name

10. Exercising both the ØLDMØDES and ØLDBØUND options concurrently the user must use the following sequence of commands:

 EDIT(32) new name (previous modal reduction name)

 EDIT(512) name

 MREDUCE name

 NAME = new name

Substructure Mode Control ØPTIØNS - Defines Matrix Types

Purpose: This allows the user to selectively control the type of matrices being processed.

Request Format:

ØPTIØNS m1,m2,m3

Subcommands: None

Definition:

m1,m2,m3 - Any combination of the characters K, M, B, K4, and either P or PA, where:

K = Stiffness Matrices
M = Mass Matrices
P = Load Matrices
PA = Appended Load Vectors
B = Viscous Damping Matrices
K4 = Structure Damping Matrices

Notes: 1. The default depends on the NASTRAN rigid format:

Rigid Format	Default
1 - Statics	K,P
2 - Inertia Relief	K,M,P
3 - Normal Modes	K,M
8 - Frequency Response	K,M,P,B,K4
9 - Transient Response	K,M,P,B,K4

2. In a Phase 1 execution, Rigid Formats 1 and 3 will provide only two of the matrices, as shown above. In Rigid Format 1, the mass matrix is not generated. In Rigid Format 3, the loads matrix is not generated. An error condition will result unless the user adds the required DMAP alters to provide the requested data.

3. Stiffness, mass, load, or damping matrices must exist if the corresponding K, M, P, PA, B, or K4 option is requested in the subsequent Phase 2 run.

4. Matrices or loads may be modified by rerunning the substructure sequence for only the desired type. However, the old data must be deleted first with the EDIT or DELETE command. See Section 1.10 for the actual item names.

5. The append load option, PA, is used when additional load sets are required for solution, and it is not desired to regenerate existing loads. To generate these new load vectors, re-execute all required Phase 1 runs with the new load sets and ØPTIØN = PA. Then, repeat the Phase 2 operations with ØPTIØN = PA. At each step, the new vectors are appended to the existing loads so that all load vectors will be available in the SØLVE stage.

6. Each ØPTIØN command overrides the preceding command to control subsequent steps of the substructure process.

7. When executing the SØLVE command, the option selected must provide the matrices required for the rigid format being executed.

Substructure Operating File Declaration PASSWØRD

Purpose: This declaration is required in the substructure command deck. The password is written on the SØF file and is used to protect the file and insure that the correct file is assigned for the current run.

Request Format:

PASSWØRD password

Subcommands: None

Definition:

password - BCD password for the SØF (8 characters maximum). See the SØF file declaration card description.

Substructure Command PLØT - Substructure Plot Command

Purpose: This operation is used to plot the undeformed shape of a substructure which may be composed of several component substructures. This command initiates the execution of a plot at any stage of the substructure process. The actual plot commands; origin data, etc., must be included in the normal case control data.

Request Format:

PLØT name

Subcommands: None

Definitions:

name - Name of component substructure to be plotted.

Notes: 1. The set of elements to be plotted will consist of all the elements and grid points saved in Phase 1 for each basic substructure comprising the substructures named in the PLØT command. (Only one plot set from each basic substructure is saved in Phase 1.)

2. The structure plotter output request packet, while part of the standard Case Control Deck, are treated separately in Sections 4.2 and 4.3, respectively.

Substructure Command RECØVER - Phase 2 Solution Data Recovery

Purpose: This operation recovers displacements and boundary forces on specified substructures in the Phase 2 execution. The results are saved on the SØF file and they may be printed upon user request. This command should be input after the SØLVE command to store the solution results on the SØF file.

Request Format:

RECØVER s-name

Subcommands:

SAVE = name

PRINT = name

DISP = {ALL / n / NØNE}

SPCF = {ALL / n / NØNE}

ØLØAD = {ALL / n / NØNE}

BASIC = b-name

ENERGY = {ALL / n / NØNE}

for static analysis only:

SØRT = {SUBCASE / SUBSTRUCTURE}

SUBCASES = {ALL / n / NØNE}

for normal modes analysis only:

SØRT = {MØDES / SUBSTRUCTURE}

MØDES = {ALL / n / NØNE}

RANGE = f_1, f_2

for dynamic analysis only:

SØRT = { FREQ / TIME / SUBSTRUCTURE }

STEPS = { ALL / n / NØNE }

RANGE = f_1, f_2

UIMPRØVE

Definitions:

s-name	- Name of the substructure named in a prior SØLVE command from which the solution results are to be recovered.
name	- Name of the component structure for which results are to be recovered. May be the same as "s-name"
b-name	- Name of component basic substructure that following output requests are to apply to.
ALL	- Output for all points will be produced.
NØNE	- No output is to be produced.
n	- Set identification number of a SET card appearing in Case Control. Only output for those points, subcases, modes, frequencies, or time steps whose identification number appears on this SET card will be produced.
f_1, f_2	- Range of frequencies or times for which output will be produced. If only f_1 is present the range is assumed to be 0 - f_1.
SUBCASE	- All output requests for each subcase will appear together.
MØDES	- All output requests for each mode will appear together.
SUBSTRUCTURE	- All output requests for each basic substructure will appear together.
TIME	- All output requests for each time step will appear together (RF 9).
FREQ	- All output requests for each frequency will appear together (RF 8).

Output Requests: Printed output produced by the RECØVER PRINT command can be controlled by requests present in either Case Control or the RECØVER command in the Substructure Control Deck. If no output requests are present, the PRINT command is equivalent to SAVE and no output will be printed.

The RECØVER output options described above may appear after any PRINT command. These output requests will then override any Case Control requests. The output requests for any PRINT command can also be specified for any or all basic component substructures of the results being recovered. These requests will then override any requests in Case Control or after the PRINT command.

Example of output control:

```
RECØVER SØLSTRCT
   PRINT    ABSC
      SØRT = SUBSTRUCTURE  }
      DISP = ALL           }   basic defaults for ABDC output
      ØLØAD = 10           }
      BASIC    A           }
         DISP = 5          }   override requests for BASIC A
      BASIC    C           }
         ØLØAD = NØNE      }
         SUBCASES = 20     }   override requests for BASIC C
   SAVE   ABC
```

Notes:

1. SAVE will save the solution for substructure "name" on the SØF. PRINT will save and print the solution.
2. If the solution data already exists on the SØF, the existing data can be printed without costs of regeneration with the PRINT command.
3. For efficiency, the user should order multiple SAVE and/or PRINT commands so as to trace one branch at a time starting from his solution structure.
4. Reaction forces are computed for a substructure only if (1) the substructure is named on a PRINT subcommand and, (2) an output request for SPCFØRCE or modal energies exists in the Case Control or the RECØVER command.
5. All set definitions should appear in Case Control to ensure their availability to the RECØVER module.
6. The SØRT output option should only appear after a PRINT command. Any SØRT commands appearing after a BASIC command will be ignored.
7. If both a MØDES (or STEPS) request and a RANGE request appear for dynamic analysis, both requests must be satisfied for any output to be produced.
8. The media, print or punch, where output is produced is controlled through Case Control requests. If no Case Control requests are present, the default of print is used.
9. If the UIMPRØVE request is present for a substructure that was input to a REDUCE, MREDUCE, or CREDUCE, an improved displacement vector will be generated. This vector will contain the effects of inertia and damping forces.
10. The ENERGY request will cause the calculation of modal energies on all included and excluded modal dof for a modal reduced substructure. This request should appear for the substructure that was input to the modal reduce operation so that required data needed for the excluded mode calculations exists. This request requires that the UVEC item exists for the next highest level structure.
11. For dynamic analysis, the printed loads output will include dynamic loads only for the solution substructure in the same run that the solution was obtained. For any lower level substructures or on any run after the solution, only static loads will be printed.
12. The user can specify print thresholds for all printout. If the absolute value is less than the threshold, the value will be set to zero. The following thresholds can be input on PARAM bulk data cards.

 UTHRESH - displacement, velocity, and acceleration
 PTHRESH - load threshold
 QTHRESH - reaction force threshold

Substructure Mode Control RUN - Specifies Run Options

Purpose: This command is used to limit the substructure execution for the purpose of checking the validity of the input data. It allows for the processing of input data separately from the actual execution of the matrix operations.

Request Format:

RUN { DRY / GØ / DRYGØ / STEP }

Subcommands: None

Definitions:

DRY - Limits the execution to table and transformation matrix generation. Matrix operations are skipped.

GØ - Limits the execution to matrix generation only. This mode must have been preceded by a successful RUN=DRY or RUN = STEP execution.

DRYGØ - Will cause execution of a complete dry run for the entire job, followed by a RUN=GØ execution if no fatal errors were detected.

STEP - Will cause the execution of both DRY and GØ operations one step at a time.

Notes:
1. The DRY, GØ, and STEP options may be changed at any step in the input substructure command sequence. If the DRYGØ option is used, the RUN card must appear only once at the beginning.
2. If a fatal error occurs during the first pass of the DRYGØ option, the program exits at the completion of all DRY operations.
3. The RUN = DRY option is handled differently for MREDUCE and CREDUCE because the matrix operations must be performed in order to generate the table and transformation matrix data. Input data only will be checked and no subsequent commands will be executed.
4. The RUN = GØ and ØPTIØNS = K combination is illegal for any of the reduce operations, REDUCE, MREDUCE, or CREDUCE.

Substructure Operation File Declaration SØF - Assigns Physical Files for Storage of the SØF

Purpose: This declaration defines the names and sizes of the physical NASTRAN files the user assigns for storage of the SØF file. At least one of these declarations must be present in each substructure command deck. As many SØF declarations are required in the substructure command deck on each run as there are physical files assigned for the storage of the SØF file.

Request Format:

SØF(no.) = filename, filesize, $\left\{\begin{matrix}\text{ØLD}\\\text{NEW}\end{matrix}\right\}$

Subcommands:

PASSWØRD = password

Definitions:

no. - Integer index of SØF file (1, 2, etc.) in ascending order of files required for storage of the SØF. The maximum index is 10.

filename - User name for an SØF physical file.

filesize - Size of allocated file space in kilowords, default = 100.

ØLD - SØF data is assumed to already exist on the file.

NEW - The SØF is new. In this case, the SØF will be initialized.

password - BCD password for the SØF (8 characters maximum) used to protect the file and insure that the correct file is assigned for the current run (see the PASSWØRD card description).

Notes:

1. If more space is required for storage of the SØF file, additional physical files may be declared. Alternately, the file size parameter on a previously declared file may be increased, but only on the last physical file if more than one is used (on IBM the size of an existing file may not be increased.

2. Once an SØF declaration is made, the index of the SØF file must always be associated with the same file name. File names may not be changed from run to run.

3. The file names of each physical SØF file must be unique.

4. The declared size of the SØF may be reduced by the amount of contiguous free-space at the end of the logical SØF file. This may be accomplished by removing the physical file declaration for those unused files which have the highest sequence numbers. An attempt to eliminate a portion of the SØF which contains valid data will result in a fatal error.

5. If the NEW parameter is present on any one of the SØF declarations, the entire logical SØF is considered new. Therefore, if an additional physical file is added to an existing SØF, the NEW parameter should not be included on any declarations.

6. The following conventions should be used for the file name declarations on each of the three NASTRAN computers:

 CDC/CYBER

 Must be a 4-character alphanumeric name with no special characters or blanks allowed. The file name used on the SØF declaration must correspond to ones used on the system REQUEST or ATTACH card. Note that after a NASTRAN execution, the SØF files should be catalogued or extended.

Substructure Command SØFIN

Purpose: To copy substructure items from an external file to the SØF.

Request Format:

SØFIN $\left(\left\{\begin{matrix}\text{EXTERNAL}\\ \underline{\text{INTERNAL}}\end{matrix}\right\}\right)$ filename $\left\{\begin{matrix},\text{DISK}\\ ,\underline{\text{TAPE}}\end{matrix}\right\}$

Subcommands:

POSITION = $\left\{\begin{matrix}\text{REWIND}\\ \underline{\text{NØREWIND}}\end{matrix}\right\}$

NAMES = $\left\{\begin{matrix}\text{substructure name}\\ \underline{\text{WHØLESØF}}\end{matrix}\right\}$

ITEMS = $\left\{\begin{matrix}\underline{\text{ALL}}\\ \text{MATRICES}\\ \text{PHASE3}\\ \text{TABLES}\\ \text{item name}\end{matrix}\right\}$

Definitions:

EXTERNAL - File was written on a different computer type.

INTERNAL - File was written with GINØ on the same computer type.

Filename - Name of the external file. If the file is in INTERNAL format, filename must specify INPT, INP1,...,INP9. If the file is in EXTERNAL format, filename must specify a FØRTRAN unit by using the form FØRT1, FØRT2,...,FØRT32.

DISK - File is located on a direct access device.

TAPE - File is located on a tape.

PØSITION - Specifies initial file position.

REWIND: file is rewound
NØREWIND: input begins at the current position

NAMES - Identifies a substructure for which data will be read. If NAMES=WHØLESØF is coded, and no other NAMES subcommands appear for the current SØFIN command, all substructure items found on the external file from the point specified by the PØSITIØN subcommand to the end-of-file are copied to the SØF.

ITEMS - Identifies the data items which are to be copied to the SØF for each substructure specified by the NAMES subcommands.

ALL: all items
MATRICES: all matrix items
PHASE3: the UVEC, QVEC, and SØLN items
TABLES: all table items
item name: name of an individual item

Notes: 1. Filename is required. The other SØFIN operands are optional.

2. All subcommands are optional.

3. The NAMES subcommand may appear up to five times for each SØFIN command.

4. If a substructure name of an item which is to be copied to the SØF does not exist on the SØF, it is added to the SØF. MDI pointers for higher level, combined substructures and lower level substructures are restored.

5. For the EXTERNAL form of this command all the items on the file are read in and added to the SØF. The PØSITIØN subcommand should be specified as REWIND and user specifications for all other subcommands are ignored.

6. SØFØUT is the companion substructure command.

7. When an internal-formated file is located on tape and extends over multiple reels, care should be taken when using the SØFIN command. The commands should be ordered so that all the desired data is retrieved on a single pass through the tape. The following suggestions are helpful:

 a. Order the SØFIN command to obtain data in the order they exist on the tape. If this order is not known, the CHECK command will list the contents of the tape.

 b. The first SØFIN command should specify PØSITIØN=REWIND and all subsequent commands should use PØSITIØN=NØREWIND.

 c. The individual items should be requested by name. The ALL, MATRICES, TABLES or PHASE3 specification should not be used for the ITEMS subcommand unless all the appropriate items are on the tape. If some are not present, the tape will be searched to the end of the last reel and subsequent commands will not be executable because they will attempt to rewind back to the first tape.

8. On IBM computers and for the EXTERNAL form of this command, the following DD card should be used:

```
//NS.FTxxF001 DD DSN=username,UNIT=2400-1,DISP=(,KEEP),
//    LABEL=(,NL),DCB=(RECFM=FB,LRECL=132,BLKSIZE=3960,
//    TRTCH=T,DEN=2)
```

9. Only one item may appear as an ITEMS subcommand per NAMES subcommand. Selective items may be referenced by repeating the NAMES subcommand.

Substructure Command SØFØUT

Purpose: To copy substructure items from the SØF to an external file.

Request Format:

SØFØUT $\left(\left\{\begin{matrix}\text{EXTERNAL}\\ \underline{\text{INTERNAL}}\end{matrix}\right\}\right)$ filename $\left\{\begin{matrix},\text{DISK}\\ \underline{\text{TAPE}}\end{matrix}\right\}$

Subcommands:

PØSITIØN = $\left\{\begin{matrix}\text{REWIND}\\ \underline{\text{NØREWIND}}\\ \text{EØF}\end{matrix}\right\}$

NAMES = $\left\{\begin{matrix}\text{substructure name}\\ \underline{\text{WHØLESØF}}\end{matrix}\right\}$

ITEMS = $\left\{\begin{matrix}\underline{\text{ALL}}\\ \text{MATRICES}\\ \text{PHASE3}\\ \text{TABLES}\\ \text{item name}\end{matrix}\right\}$

Definitions:

EXTERNAL - File will be written so that it may be read on a different computer type.

INTERNAL - File will be written with GINØ.

Filename - Name of the external file. If the file is in INTERNAL format, filename must specify INPT, INP1,...,INP9. If the file is in EXTERNAL format, filename must specify a FØRTRAN unit by using the form FØRT1, FØRT2,...,FØRT32.

DISK - File is located on a direct access device.

TAPE - File is located on a tape.

PØSITIØN - Specifies initial file position. (See Note 6)

REWIND: file is rewound
NØREWIND: output begins at the current position
EØF: file is positioned to the point immediately preceding the end-of-file mark.

NAMES - Identifies a substructure for which data will be written. If NAMES=WHØLESØF is coded and no other NAMES subcommands appear for the current SØFØUT command, all substructure items found on the SØF are copied to the external file.

ITEMS - Identifies the data items which are to be copied to the external file for each substructure specified by the NAMES subcommands.

ALL: all items
MATRICES: all matrix items
PHASE3: the UVEC, QVEC, and SØLN items
TABLES: all table items
item names: name of an individual item

Notes: 1. Filename is required. The other SØFØUT operands are optional.

2. All subcommands are optional.

3. The NAMES subcommand may appear up to five times for each SØFØUT command.

4. PLTS items of pseudostructures reference the PLTS items of the component basic substructures. Therefore, in order to save all data necessary to plot a pseudostructure, the PLTS items of its component basic substructures must be saved as well as the PLTS item of the pseudostructure.

5. For the external form of this command, PØSITIØN=NØREWIND has the effect of positioning the file to the end-of-file.

6. PØSITIØN=REWIND should be coded for the first write to a new file.

7. SØFIN is the companion substructure command.

8. On IBM computers and for the EXTERNAL form of this command, the following DD card should be used:

```
//NS.FTxxF001 DD DSN=username,UNIT=2400-1,DISP=(,KEEP),
//    LABEL=(,NL),DCB=(RECFM=FB,LRECL=132,BLKSIZE=3960,
//    TRTCH=T,DEN=2)
```

9. Only one item may appear as an ITEMS subcommand per NAMES subcommand. Selective items may be referenced by repeating the NAMES subcommand.

Substructure Command SØFPRINT - Requests SØF File Verification

Purpose: To print selected contents of the SØF file for data checking purposes.

Request Format:

SØFPRINT(opt) name, item1, item2, etc.

Subcommands: None

Definitions:

opt - Integer, control option, default = 0.

opt = 1: prints data items only
opt = 0: prints table of contents
opt = -1: prints both

name - Name of substructure for which data is to be printed.

item1, item2 - SØF item name, used only when opt ≠ 0, limit = 5 (see Table 2, Section 1.10.2).

Notes: 1. If only the table of contents is desired (opt = 0) this command may be coded:

SØFPRINT TØC

On the page heading for the table of contents, the labels are defined as follows:

SS - Secondary substructure number (successor)
PS - Primary substructure number (predecessor)
LL - Lower level substructure number
CS - Combined substructure number
HL - Higher level substructure number
TYPE - Substructure type

B - basic substructure
C - combined substructure
R - Guyan reduced substructure
M - real modal reduced substructure
CM - complex modal reduced substructure

Any of the above types will have a prefix "I" if it is an image substructure resulting from an EQUIV operation.

Substructure Command SØLVE - Substructure Solution

Purpose: This command initiates the substructure solution phase. The tables and matrices for the pseudostructure are converted to their equivalent NASTRAN data blocks. The substructure grid points referenced on bulk data cards SPCS, MPCS, etc., are converted to pseudostructure scalar point identification numbers. The NASTRAN execution then proceeds as though a normal structure were being processed.

Request Format:

SØLVE name

Subcommands: None (Case Control and bulk data decks control the operations.)

Definition:

name - Name of pseudostructure to be analyzed with NASTRAN.

Notes:
1. The allowable NASTRAN Rigid Formats are 1, 2, 3, 8, and 9.
2. Before requesting a SØLVE, the user should check to be sure that all necessary matrices are available on the SØF file. For instance, loads and stiffness matrices are necessary in statics analysis. Mass and stiffness matrices are necessary in eigenvalue analysis, etc.
3. If the ØPTIØNS command has been used, an additional ØPTIØNS command may be necessary to ensure that the matrices required are available for the SØLVE operation.
4. Static load combinations of the original Phase 1 load vectors may be defined by the bulk data card LØADC. Loads of this type may be used in Rigid Format 9 (Direct Transient Analysis) in lieu of DAREA dynamic load data.
5. The SØLVE name command should always be followed by RECØVER name to assure the solution data are saved on the SØF.
6. The SØLVE command may only be used in Phase 2 executions.

3.2 STATIC ANALYSIS

3.2.1 DMAP Sequence for Static Analysis

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 1

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN    NO.1 STATIC ANALYSIS - SERIES P $

    2  FILE     OPTP2=SAVE/EST1=SAVE $

    3  FILE     OG=APPEND/PGG=APPEND/UGV=APPEND/GM=SAVE/KNN=SAVE $

    4  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT/V,N,ALWAYS=-1 $

    5  SAVE     LUSET $

    6  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

    7  GP2      GEOM2,EQEXIN/ECT $

    8  CHKPNT   ECT $

    9  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

   10  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

   11  COND     P1,NOPCDB $

   12  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
                JUMPPLOT=-1 $

   13  SAVE     NSIL,JUMPPLOT $

   14  PRTMSG   PLTSETX// $

   15  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

   16  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

   17  COND     P1,JUMPPLOT $

   18  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $


   19  SAVE     JUMPPLOT,PLTFLG,PFILE $

   20  PRTMSG   PLOTX1// $

   21  LABEL    P1 $

   22  CHKPNT   PLTPAR,GPSETS,ELSETS $

   23  GP3      GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV/V,N,NFVER=1 $
```

```
RIGID FORMAT DMAP LISTING
SERIES 9

DISPLACEMENT APPROACH, RIGID FORMAT 1

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


24  SAVE      NOGRAV $
25  PARAM     //C,N,AND/V,N,NOMGG/V,N,NOGRAV/V,Y,GRDPNT=-1 $
26  CHKPNT    SLT,GPTT $
27  TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,,,/V,N,LUSET/V,N,
              NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $
28  SAVE      NOSIMP,NOGENL,GENEL $
29  PARAM     //C,N,AND/V,N,NOELMT/V,N,NOGENL/V,N,NOSIMP $
30  COND      ERROR4,NOELMT $
31  PURGE     KGGX,GPST/NOSIMP/OGPST/GENEL $
32  CHKPNT    EST,GPECT,GEI,GPST,OGPST $
33  OPTPR1    MPT,EPT,ECT,DIT,EST/OPTP1/V,N,PRINT/V,N,TSTART/V,N,COUNT $
34  SAVE      PRINT,TSTART,COUNT $
35  CHKPNT    OPTP1 $
36  PARAM     //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
37  JUMP      LOOPTOP $
38  LABEL     LOOPTOP $                          Top of Optimization Loop
39  COND      LBL1,NOSIMP $
40  PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $
41  EQUIV     OPTP1,OPTP2/NEVER/EST,EST1/NEVER $
42  EMG       EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
              N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
              CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,

              CPODPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $
43  SAVE      NOKGGX,NOMGG $
44  CHKPNT    KELM,KDICT,MELM,MDICT $
45  COND      JMPKGG,NOKGGX $
46  EMA       GPECT,KDICT,KELM/KGGX,GPST $
47  CHKPNT    KGGX,GPST $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 1

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


48  LABEL   JMPKGG $
49  COND    JMPMGG,NOMGG $
50  EMA     GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $
51  CHKPNT  MGG $
52  LABEL   JMPMGG $
53  COND    LBL1,GRDPNT $
54  COND    ERROR2,NOMGG $
55  GPWG    BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS $
56  OFP     OGPWG,,,,,// $
57  LABEL   LBL1 $
58  EQUIV   KGGX,KGG/NOGENL $
59  CHKPNT  KGG $
60  COND    LBL11A,NOGENL $
61  SMA3    GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
62  CHKPNT  KGG $
63  LABEL   LBL11A $
64  PARAM   //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
65  JUMP    LBL11 $
                                                        Top of DMAP Loop
66  LABEL   LBL11 $
67  GP4     CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N,LUSET/
            V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,

            N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
68  SAVE    MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $
69  COND    ERROR3,NOL $
70  PARAM   //C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT $
71  PURGE   KRR,KLR,QR,DM/REACT/GM/MPCF1/GO,KOO,LOO,PO,UOOV,RUOV/OMIT/PS,
            KFS,KSS/SINGLE/OG/NOSR $
72  CHKPNT  KRR,KLR,QR,DM,GM,GO,KOO,LOO,PO,UOOV,RUOV,PS,KFS,KSS,OG,USET,RG,
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 1

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

                YS,ASET $
 73  COND       LBL4,GENEL $
 74  GPSP       GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
 75  SAVE       NOGPST $
 76  COND       LBL4,NOGPST $
 77  OFP        OGPST,,,,,// $
 78  LABEL      LBL4 $
 79  EQUIV      KGG,KNN/MPCF1 $
 80  CHKPNT     KNN $
 81  COND       LBL2,MPCF2 $
 82  MCE1       USET,RG/GM $
 83  CHKPNT     GM $
 84  MCE2       USET,GM,KGG,,,/KNN,,, $
 85  CHKPNT     KNN $
 86  LABEL      LBL2 $
 87  EQUIV      KNN,KFF/SINGLE $
 88  CHKPNT     KFF $
 89  COND       LBL3,SINGLE $
 90  SCE1       USET,KNN,,,/KFF,KFS,KSS,,, $
 91  CHKPNT     KFS,KSS,KFF $
 92  LABEL      LBL3 $

 93  EQUIV      KFF,KAA/OMIT $
 94  CHKPNT     KAA $
 95  COND       LBL5,OMIT $
 96  SMP1       USET,KFF,,,/GO,KAA,KOO,LOO,,,, $
 97  CHKPNT     GO,KAA,KOO,LOO $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 1

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


 98  LABEL    LBL5 $
 99  EQUIV    KAA,KLL/REACT $
100  CHKPNT   KLL $
101  COND     LBL6,REACT $
102  RBMG1    USET,KAA,/KLL,KLR,KRR,,, $
103  CHKPNT   KLL,KLR,KRR $
104  LABEL    LBL6 $
105  RBMG2    KLL/LLL $
106  CHKPNT   LLL $
107  COND     LBL7,REACT $
108  RBMG3    LLL,KLR,KRR/DM $
109  CHKPNT   DM $
110  LABEL    LBL7 $
111  SSG1     SLT,BGPDT,CSTM,SIL,EST,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/V,N,
              LUSET/V,N,NSKIP $
112  CHKPNT   PG $
113  EQUIV    PG,PL/NOSET $
114  CHKPNT   PL $
115  COND     LBL10,NOSET $
116  SSG2     USET,GM,YS,KFS,GO,DM,PG/QR,PO,PS,PL $
117  CHKPNT   QR,PO,PS,PL $


118  LABEL    LBL10 $
119  SSG3     LLL,KLL,PL,LOO,KOO,PO/ULV,UOOV,RULV,RUOV/V,N,OMIT/V,Y,IRES=-1/
              V,N,NSKIP/V,N,EPSI $
120  SAVE     EPSI $
121  CHKPNT   ULV,UOOV,RULV,RUOV $
122  COND     LBL9,IRES $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 1

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


123  MATGPR    GPL,USET,SIL,RULV//C,N,L $
124  MATGPR    GPL,USET,SIL,RUOV//C,N,O $
125  LABEL     LBL9 $
126  SDR1      USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,QR/UGV,PGG,QG/V,N,NSKIP/
               C,N,STATICS $
127  CHKPNT    UGV,PGG,QG $
128  COND      LBL8,REPEAT $
129  REPT      LBL11,360 $                                  Bottom of DMAP Loop
130  JUMP      ERROR1 $
131  PARAM     //C,N,NOT/V,N,TEST/V,N,REPEAT $
132  COND      ERROR5,TEST $
133  LABEL     LBL8 $
134  CHKPNT    CSTM $
135  GPFDR     CASECC,UGV,KELM,KDICT,ECT,EQEXIN,GPECT,PGG,QG/ONRGY1,OGPFB1/
               C,N,STATICS $
136  OFP       ONRGY1,OGPFB1,,,,// $
137  COND      NOMPCF,GRDEQ $
138  EQMCK     CASECC,EQEXIN,GPL,BGPDT,SIL,USET,KGG,GM,UGV,PGG,QG,CSTM/  OQM1/
               V,Y,OPT=O/V,Y,GRDEQ/V,N,NSKIP $
139  OFP       OQM1,,,,,//V,N,CARDNO $
140  SAVE      CARDNO $
141  LABEL     NOMPCF $


142  SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QG,UGV,EST,
               XYCDB,PGG/OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,STATICS/V,N,
               NOSORT2=-1/C,N,-1 $
143  SAVE      NOSORT2 $
144  CURV      OES1,MPT,CSTM,EST,SIL,GPL/OES1M,OES1G/ C,Y,STRESS/C,Y,NINTPTS $
145  SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,,UGV,EST,,/ ,,,
               OES1A,,/C,N,STATICS//C,N,1 $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 1

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


146 CURV     OES1A,MPT,CSTM,EST,SIL,GPL/OES1AM,OES1AG/  C,Y,STRAIN/C,Y,
             NINTPTS $
147 COND     LBL17,NOSORT2 $
148 SDR3     OUGV1,OPG1,OQG1,OEF1,OES1,/OUGV2,OPG2,OQG2,OEF2,OES2, $
149 OFP      OUGV2,OPG2,OQG2,OEF2,OES2,//V,N,CARDNO $
150 SAVE     CARDNO $
151 OFP      OES1M,OES1G,OES1A,OES1AM,OES1AG,//V,N,CARDNO $
152 SAVE     CARDNO $
153 XYTRAN   XYCDB,OPG2,OQG2,OUGV2,OES2,OEF2/XYPLTT/C,N,TRAN/C,N,PSET/V,N,
             PFILE/V,N,CARDNO $
154 SAVE     PFILE,CARDNO $
155 XYPLOT   XYPLTT// $

156 JUMP     DPLOT $
157 LABEL    LBL17 $
158 COND     LBLOFP,COUNT $
159 OPTPR2   OPTP1,OES1,EST/OPTP2,EST1/V,N,PRINT/V,N,TSTART/V,N,COUNT/V,N,
             CARDNO $
160 SAVE     CARDNO,COUNT,PRINT $
161 EQUIV    EST1,EST/ALWAYS/OPTP2,OPTP1/ALWAYS $
162 COND     LOOPEND,PRINT $
163 LABEL    LBLOFP $

164 OFP      OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $
165 SAVE     CARDNO $
166 OFP      OES1M,OES1G,OES1A,OES1AM,OES1AG,//V,N,CARDNO $
167 SAVE     CARDNO $
168 COND     P2,JUMPPLOT $
169 LABEL    DPLOT $
170 PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,,GPECT,OES1/
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 1

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

                PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
171   SAVE      PFILE $
172   PRTMSG    PLOTX2// $
173   LABEL     P2 $
174   LABEL     LOOPEND $
175   COND      FINIS,COUNT $
176   REPT      LOOPTOP,360 $
177   JUMP      FINIS $
178   LABEL     ERROR1 $
179   PRTPARM   //C,N,-1/C,N,STATICS $
180   LABEL     ERROR2 $
181   PRTPARM   //C,N,-2/C,N,STATICS $
182   LABEL     ERROR3 $
183   PRTPARM   //C,N,-3/C,N,STATICS $
184   LABEL     ERROR4 $
185   PRTPARM   //C,N,-4/C,N,STATICS $
186   LABEL     ERROR5 $
187   PRTPARM   //C,N,-5/C,N,STATICS $
188   LABEL     FINIS $
189   END       $
```

Bottom of Optimization Loop

3.2.2 Description of DMAP Operations for Static Analysis

4. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

7. GP2 generates Element Connection Table with internal indices.

11. Go to DMAP No. 21 if no plot output is requested.

12. PLTSET transforms user input into a form used to drive structure plotter.

14. PRTMSG prints error messages associated with structure plotter.

17. Go to DMAP No. 21 if no undeformed structure plots are requested.

18. PLØT generates all requested undeformed structure plots.

20. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

23. GP3 generates Static Loads Table and Grid Point Temperature Table.

27. TA1 generates element tables for use in matrix assembly and stress recovery.

30. Go to DMAP No. 184 and print error message if no elements have been defined.

33. ØPTPR1 performs phase one property optimization and initialization check.

37. Go to next DMAP instruction if cold start or modified restart. LØØPTØP will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

38. Beginning of Loop for property optimization.

39. Go to DMAP No. 57 if there are no structural elements.

42. EMG generates structural element stiffness and mass matrix tables and dictionaries for later assembly.

45. Go to DMAP No. 48 if no stiffness matrix is to be assembled.

46. EMA assembles stiffness matrix $[K^{x}_{gg}]$ and Grid Point Singularity Table.

49. Go to DMAP No. 52 if no mass matrix is to be assembled.

50. EMA assembles mass matrix $[M_{gg}]$.

53. Go to DMAP No. 57 if no weight and balance is requested.

54. Go to DMAP No. 180 and print error message if no mass matrix exists.

55. GPWG generates weight and balance information.

56. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

58. Equivalence $[K^{x}_{gg}]$ to $[K_{gg}]$ if no general elements.

60. Go to DMAP No. 63 if no general elements.

61. SMA3 adds general elements to $[K^{x}_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

65. Go to next DMAP instruction if cold start or modified restart. LBL11 will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

66. Beginning of Loop for additional constraint sets

67. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

69. Go to DMAP No. 182 and print error message if no independent degrees of freedom are defined.

73. Go to DMAP No. 78 if general elements present.

74. GPSP determines if possible grid point singularities remain.

76. Go to DMAP No. 78 if no grid point singularities remain.

77. ØFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

79. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

81. Go to DMAP No. 86 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

82. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

84. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] .$$

87. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

89. Go to DMAP No. 92 if no single-point constraints.

90. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] .$$

93. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

95. Go to DMAP No. 98 if no omitted coordinates.

96. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right] ,$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

99. Equivalence $[K_{aa}]$ to $[K_{\ell\ell}]$ if no free-body supports.

101. Go to DMAP No. 104 if no free-body supports.

102. RBMG1 partitions out-free body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] .$$

105. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

107. Go to DMAP No. 110 if no free-body supports.

108. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}] ,$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D] ,$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||} .$$

111. SSG1 generates static load vectors $\{P_g\}$.

113. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

116. SSG2 applies constraints to static load vectors

$$\{P_g\} = \left\{\begin{array}{c} \bar{P}_n \\ \hline P_m \end{array}\right\} , \quad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\} ,$$

$$\{P_n\} = \left\{\begin{array}{c} \bar{P}_f \\ \hline P_s \end{array}\right\} , \quad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\} ,$$

$$\{P_f\} = \left\{\begin{array}{c} \bar{P}_a \\ \hline P_o \end{array}\right\} , \quad \{P_a\} = \{\bar{P}_a\} + [G_o^T]\{P_o\} ,$$

$$\{P_a\} = \left\{\begin{array}{c} P_\ell \\ \hline P_r \end{array}\right\}$$

and calculates determinate forces of reaction $\{q_r\} = -\{P_r\} - [D^T]\{P_\ell\}$.

119. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell\} ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\} ,$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{\ell\ell}]\{u_\ell\} ,$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\} ,$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o^o\}}$$

122. Go to DMAP No. 125 if residual vectors are not to be printed.

123. MATGPR prints the residual vector for independent coordinates (RULV)

124. MATGPR prints the residual vector for omitted coordinates (RUØV).

126. SDR1 recovers dependent displacements

$$\left\{\begin{matrix} u_\ell \\ \hline u_r \end{matrix}\right\} = \{u_a\} , \qquad \{u_o\} = [G_o]\{u_a\} + \{u_o^o\} ,$$

$$\left\{\begin{matrix} u_a \\ \hline u_o \end{matrix}\right\} = \{u_f\} , \qquad \left\{\begin{matrix} u_f \\ \hline Y_s \end{matrix}\right\} = \{u_n\} ,$$

$$\{u_m\} = [G_m]\{u_n\} , \qquad \left\{\begin{matrix} u_n \\ \hline u_m \end{matrix}\right\} = \{u_g\} ,$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\}.$$

128. Go to DMAP No. 133 if all constraint sets have been processed.

129. Go to DMAP No. 66 if additional sets of constraints need to be processed.

130. Go to DMAP No. 178 and print error message if number of loops exceeds 360.

132. Go to DMAP No. 186 and print error message if multiple boundary conditions are attempted with improper subset.

135. GPFDR calculates the grid point force balance (ØGPFB1) and element strain energy (ONRGY1) for requested sets.

136. ØFP formats tables prepared by GPFDR and places them on the system output file for printing.

137. Go to DMAP No. 141 if no multi-point constraint force balance is requested.

138. EQMCK calculates the force and moment equilibrium check and prepares the multi-point constraint force balance (ØQM1) for output.

139. ØFP formats tables prepared by EQMCK and places them on the system output file for printing.

144. CURV calculates element stresses in material coordinate system (ØES1M) and stresses at the connected grid points (ØES1G).

145. SDR2 calculates element strains/curvatures (ØES1A).

146. CURV calculates element strains/curvatures in material coordinate system (ØES1AM) and strains/curvatures at the connected grid points (ØES1AG).

147. Go to DMAP No. 157 if no output requests for grid point number or element number sort.

148. SDR3 prepares requested output sorted by grid point number of element number.

149. ØFP formats tables prepared by SDR3 for output sorted by grid point number or element number and places it on the system output file for printing.

151. ØFP formats tables prepared by CURV and SDR2 and places them on the system output file for printing.

153. XYTRAN prepares the input for requested X-Y plots.

155. XYPLØT prepares requested X-Y plots of displacements, forces, stresses, loads or single-point forces of constraint vs. subcase.

156. Go to DMAP No. 169 because printed output is not requested by subcase number.

158. Go to DAMP No. 163 if no phase two property optimization.

159. ØPTPR2 performs phase two property optimization.

161. Equivalence EST1 to EST and ØPTP2 to ØPTP1 everytime this instruction is executed.

162. Go to DMAP No. 174 if no additional output is to be printed for this loop.

164. ØFP formats tables prepared by SDR2 for output sorted by subcase number and places them on the system output file for printing.

168. Go to DMAP No. 143 if no deformed structure plots are requested.

170. PLØT generates all requested deformed structure and contour plots.

172. PRTMSG prints plotter data, engineering data, and contour data for each deformed plot generated.

175. Go to DMAP No. 188 and make a normal exit if property optimization is complete.

176. Go to DMAP No. 38 if additional loops for property optimization are needed.

177. Go to DMAP No. 188 and make normal exit.

179. STATIC ANALYSIS ERRØR MESSAGE NØ. 1 - ATTEMPT TØ EXECUTE MØRE THAN 360 LØØPS.

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY.

181. STATIC ANALYSIS ERRØR MESSAGE NØ. 2 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

183. STATIC ANALYSIS ERRØR MESSAGE NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

185. STATIC ANALYSIS ERRØR MESSAGE NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

187. STATIC ANALYSIS ERROR MESSAGE NØ. 5 - A LØØPING PRØBLEM RUN ØN NØN-LØØPING SUBSET.

3.2.3 Case Control Deck and Parameters for Static Analysis

The following items relate to subcase definition and data selection for Static Analysis:

1. A separate subcase must be defined for each unique combination of constraints and static loads.
2. A static loading condition must be defined for (not necessarily within) each subcase with a LØAD, TEMPERATURE(LØAD), or DEFØRM selection unless all loading is specified with grid point displacements on SPC cards.
3. An SPC set must be selected for (not necessarily within) each subcase, unless the model is a properly supported free body, or all constraints are specified on GRID cards, Scalar Connection cards, or with General Elements.
4. Loading conditions associated with the same sets of constraints should be in contiguous subcases in order to avoid unnecessary looping.
5. REPCASE may be used to repeat subcases in order to allow multiple sets of the same output item.

The following printed output, sorted by loads (SØRT1) or by grid point number or element number (SØRT2), may be requested for Static Analysis solutions:

1. Displacements and components of static loads and single-point forces of constraint at selected grid points or scalar points.
2. Forces and stresses in selected elements.

The following plotter output may be requested for Static Analysis solutions:

1. Undeformed and deformed plots of the structural model.
2. Contour plots of stress and displacement.
3. X-Y plot of any component of displacement, static load, or single-point force of constraint for a grid point or scalar point versus subcase.
4. X-Y plot of any stress or force component for an element versus subcase.

The following parameters are used in Static Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.

2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in EMA.

3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.

4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices, rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

5. ØPT - optional in static and normal modes analyses (rigid formats 1, 2, 3, 14, and 15). A positive integer value of this parameter causes both equilibrium and multipoint constraint forces to be calculated for the Case control output request, MPCFØRCE. A negative integer value of this parameter causes only the equilibrium force balance to be calculated for the output request. The default value is 0 which causes only the multipoint constraint forces to be calculated for the output request.

6. GRDEQ - optional in static and normal modes analyses (rigid formats 1, 2, 3, 14, and 15). A positive integer value of this parameter selects the grid point about which equilibrium will be checked for the Case Control output request, MPCFØRCE. If the integer value is zero, the basic origin is used. Default is -1.

7. STRESS - optional in static analysis (rigid format 1). This parameter controls the transformation of element stresses to the material coordinate system (only for TRIA1, TRIA2, QUAD1 and QUAD2 elements). If it is a positive integer, the stresses for these elements are transformed to the material coordinate system. If it is zero, stresses at the connected grid points are also computed in addition to the element stresses in the material coordinate system. A negative integer value results in no transformation of the stresses. The default value is -1.

8. STRAIN - optional in static analysis (rigid format 1). This parameter controls the transformation of element strains/curvatures to the material coordinate system (only for TRIA1, TRIA2, QUAD1 and QUAD2 elements). If it is a positive integer, the strains/curvatures for these elements are transformed to the material coordinate system. If it is zero, strains/curvatures at the connected grid points are also computed in addition to the element strains/curvatures in the material coordinate system. A negative

integer value results in no transformation of the strains/curvatures. The default value is -1.

9. NINTPTS - optional in static analysis (rigid format 1). A positive integer value of this parameter specifies the number of closest independent points to be used in the interpolation for computing stresses or strains/curvatures at grid points (only for TRIA1, TRIA2, QUAD1 and QUAD2 elements). A negative integer value or 0 specifies that all independent points are to be used in the interpolation. The default value is 0.

3.2.4 Automatic Alters for Automated Multi-stage Substructuring

The following lines of the Static Analysis, Rigid Format 1, are altered for automatic substructure analyses.

Phase 1: 3, 69, 100-110, 113-116

Phase 2: 2, 4-5, 9-22, 29-30, 41, 58-61, 73-78, 134-164

Phase 3: 100-110, 115-125, 127

If APP DISP,SUBS is used, the user may also specify ALTER's. However, these must not interfere with the automatically generated DMAP statement ALTER's listed above. See Section 5.9 for a description and listing of the ALTER's which are automatically generated for substructuring.

..3 STATIC ANALYSIS WITH INERTIA RELIEF

3.3.1 DMAP Sequence for Static Analysis with Inertia Relief

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 2

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN    NO.2 STATIC ANALYSIS WITH INERTIA RELIEF - SERIES P $

    2  FILE     OG=APPEND/PGG=APPEND/UGV=APPEND/GM=SAVE/KNN=SAVE/MNN=SAVE $

    3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT $

    4  SAVE     LUSET $

    5  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

    6  GP2      GEOM2,EQEXIN/ECT $

    7  CHKPNT   ECT $

    8  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

    9  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

   10  COND     P1,NOPCDB $

   11  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
                JUMPPLOT=-1 $

   12  SAVE     NSIL,JUMPPLOT $

   13  PRTMSG   PLTSETX// $

   14  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

   15  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

   16  COND     P1,JUMPPLOT $

   17  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

   18  SAVE     JUMPPLOT,PLTFLG,PFILE $


   19  PRTMSG   PLOTX1// $

   20  LABEL    P1 $

   21  CHKPNT   PLTPAR,GPSETS,ELSETS $

   22  GP3      GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $

   23  CHKPNT   SLT,GPTT $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 2

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


24  TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,,,/V,N,LUSET/V,N,
              NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

25  SAVE      NOSIMP,NOGENL,GENEL $

26  COND      ERROR1,NOSIMP $


27  PURGE     OGPST/GENEL $

28  CHKPNT    EST,GPECT,GEI,OGPST $

29  PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

30  PARAM     //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

31  EMG       EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
              N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
              CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
              CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

32  SAVE      NOKGGX,NOMGG $

33  CHKPNT    KELM,KDICT,MELM,MDICT $

34  COND      JMPKGG,NOKGGX $

35  EMA       GPECT,KDICT,KELM/KGGX,GPST $

36  CHKPNT    KGGX,GPST $

37  LABEL     JMPKGG $

38  COND      ERROR1,NOMGG $

39  EMA       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

40  CHKPNT    MGG $

41  COND      LGPWG,GRDPNT $


42  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $

43  OFP       OGPWG,,,,,// $

44  LABEL     LGPWG $

45  EQUIV     KGGX,KGG/NOGENL $

46  CHKPNT    KGG $

47  COND      LBL11A,NOGENL $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 2

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


48  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
49  CHKPNT   KGG $
50  LABEL    LBL11A $
51  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
52  JUMP     LBL11 $
                                                    Top of DMAP Loop
53  LABEL    LBL11 $
54  GP4      CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N,LUSET/
             V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
             N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
55  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $
56  COND     ERROR3,NOL $
57  COND     ERROR4,REACT $
58  PURGE    GM/MPCF1/GO,KOO,LOO,MOO,MOA,PO,UOOV,RUOV/OMIT/KSS,KFS,PS/
             SINGLE $
59  CHKPNT   GM,RG,GO,KOO,LOO,MOO,MOA,PO,KSS,KFS,YS,PS,USET,ASET,RUOV $
60  COND     LBL4,GENEL $
61  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
62  SAVE     NOGPST $
63  COND     LBL4,NOGPST $
64  OFP      OGPST,,,,,// $
65  LABEL    LBL4 $
66  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1 $

67  CHKPNT   KNN,MNN $
68  COND     LBL2,MPCF2 $
69  MCE1     USET,RG/GM $
70  CHKPNT   GM $
71  MCE2     USET,GM,KGG,MGG,,/KNN,MNN,, $
72  CHKPNT   KNN,MNN $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 2

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


73   LABEL     LBL2 $
74   EQUIV     KNN,KFF/SINGLE/MNN,MFF/SINGLE $
75   CHKPNT    KFF,MFF $
76   COND      LBL3,SINGLE $
77   SCE1      USET,KNN,MNN,,/KFF,KFS,KSS,MFF,, $
78   CHKPNT    KFS,KSS,KFF,MFF $
79   LABEL     LBL3 $
80   EQUIV     KFF,KAA/OMIT/ MFF,MAA/OMIT $
81   CHKPNT    KAA,MAA $
82   COND      LBL5,OMIT $
83   SMP1      USET,KFF,MFF,,/GO,KAA,KOO,LOO,MAA,MOO,MOA,, $
84   CHKPNT    GO,KAA,KOO,LOO,MAA,MOO,MOA $
85   LABEL     LBL5 $
86   RBMG1     USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $
87   CHKPNT    KLL,KLR,KRR,MLL,MLR,MRR $
88   RBMG2     KLL/LLL $
89   CHKPNT    LLL $
90   RBMG3     LLL,KLR,KRR/DM $
91   CHKPNT    DM $
92   RBMG4     DM,MLL,MLR,MRR/MR $

93   CHKPNT    MR $
94   SSG1      SLT,BGPDT,CSTM,SIL,EST ,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/V,N,
               LUSET/V,N,NSKIP $
95   CHKPNT    PG $
96   SSG2      USET,GM,YS,KFS,GO,DM,PG/QR,PO,PS,PL $
97   CHKPNT    QR,PO,PS,PL $
98   SSG4      PL,QP,PO,MP,MLR,DM,MLL,MOO,MOA,GO,USET/PLI,POI/V,N,OMIT $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 2

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


 99  CHKPNT   PLI,POI $
100  SSG3     LLL,KLL,PLI,LOO,KOO,POI/ULV,UOOV,RULV,RUOV/V,N,OMIT/V,Y,
              IRES=-1/V,N,NSKIP/V,N,EPSI $
101  SAVE     EPSI $
102  CHKPNT   ULV,UOOV,RULV,RUOV $
103  COND     LBL9,IRES $
104  MATGPR   GPL,USET,SIL,RULV//C,N,L $
105  MATGPR   GPL,USET,SIL,RUOV//C,N,O $
106  LABEL    LBL9 $
107  SDR1     USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,QR/UGV,PGG,QG/V,N,NSKIP/
              C,N,STATICS $
108  CHKPNT   UGV,QG,PGG $
109  COND     LBL8,REPEAT $
110  REPT     LBL11,360 $
                                                    Bottom of DMAP Loop
111  JUMP     ERROR2 $
112  PARAM    //C,N,NOT/V,N,TEST/V,N,REPEAT $
113  COND     ERROR5,TEST $
114  LABEL    LBL8 $
115  CHKPNT   CSTM $
116  COND     NOMPCF,GRDEQ $
117  EQMCK    CASECC,EQEXIN,GPL,BGPDT,SIL,USET,KGG,GM,UGV,PGG,QG,CSTM/  OQM1/
              V,Y,OPT=O/V,Y,GRDEQ/V,N,NSKIP $
118  OFP      OQM1,,,,,//V,N,CARDNO $
119  SAVE     CARDNO $
120  LABEL    NOMPCF $
121  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QG,UGV,EST,,PGG/
              OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,STATICS $
122  PARAM    //C,N,MPY/V,N,CARDNO/C,N,O/C,N,O $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 2

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


123  OFP      OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $
124  SAVE     CARDNO $
125  COND     P2,JUMPPLOT $
126  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,,GPECT,OES1/
              PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
127  SAVE     PFILE $
128  PRTMSG   PLOTX2// $
129  LABEL    P2 $
130  JUMP     FINIS $
131  LABEL    ERROR1 $
132  PRTPARM  //C,N,-1/C,N,INERTIA $
133  LABEL    ERROR2 $
134  PRTPARM  //C,N,-2/C,N,INERTIA $
135  LABEL    ERROR3 $
136  PRTPARM  //C,N,-3/C,N,INERTIA $
137  LABEL    ERROR4 $
138  PRTPARM  //C,N,-4/C,N,INERTIA $
139  LABEL    ERROR5 $
140  PRTPARM  //C,N,-5/C,N,INERTIA $
141  LABEL    FINIS $
142  END      $
```

3.3.2 Description of DMAP Operations for Static Analysis with Inertia Relief

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot output is requested.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plots are requested.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Static Loads Table and Grid Point Temperature Table.

24. TA1 generates element tables for use in matrix assembly and stress recovery.

26. Go to DMAP No. 131 and print error message if there are no structural elements.

31. EMG generates structural element stiffness and mass matrix tables and dictionaries for later assembly.

34. Go to DMAP No. 37 if no stiffness matrix is to be assembled.

35. EMA assembles stiffness matrix $[K^{x}_{gg}]$ and Grid Point Singularity Table.

38. Go to DMAP No. 131 and print error message if no mass matrix exists.

39. EMA assembles mass matrix $[M_{gg}]$.

41. Go to DMAP No. 44 if no weight and balance is requested.

42. GPWG generates weight and balance information.

43. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

45. Equivalence $[K^{x}_{gg}]$ to $[K_{gg}]$ if no general elements.

47. Go to DMAP No. 50 if no general elements.

48. SMA3 adds general elements to $[K^{x}_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

52. Go to next DMAP instruction if cold start or modified restart. LBL11 will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

53. Beginning of Loop for additional constraint sets.

54. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

56. Go to DMAP No. 135 and print error message if no independent degrees of freedom are defined.

57. Go to DMAP No. 137 and print error message if no free-body supports.

60. Go to DMAP No. 65 if general elements present.

61. GPSP determines if possible grid point singularities remain.

63. Go to DMAP No. 65 if grid point singularities remain.

64. ØFP formats table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

66. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

68. Go to DMAP No. 73 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

69. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

71. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \quad \text{and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m].$$

74. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

76. Go to DMAP No. 79 if no single-point constraints.

77. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right].$$

80. Equivalence $[K_{ff}]$ to $[K_{aa}]$ and $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

82. Go to DMAP No. 85 if no omitted coordinates.

83. SMP1 partitions constrained stiffness and mass matrices

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right] \quad \text{and} \quad [M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right],$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reductions $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

and $[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o].$

86. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] \quad \text{and} \quad [M_{aa}] = \left[\begin{array}{c|c} M_{\ell\ell} & M_{\ell r} \\ \hline M_{r\ell} & M_{rr} \end{array}\right] .$$

88. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

90. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||}$$

92. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

94. SSG1 generates static load vectors $\{P_g\}$.

96. SSG2 applies constraints to static load vectors

$$\{P_g\} = \left\{\begin{array}{c} \bar{P}_n \\ \hline P_m \end{array}\right\}, \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\},$$

$$\{P_n\} = \left\{\begin{array}{c} \bar{P}_f \\ \hline P_s \end{array}\right\}, \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\},$$

$$\{P_f\} = \left\{\begin{array}{c} \bar{P}_a \\ \hline P_o \end{array}\right\}, \qquad \{P_a\} = \{\bar{P}_a\} + [G_o^T]\{P_o\},$$

$$\{P_a\} = \left\{\begin{array}{c} P_\ell \\ \hline P_r \end{array}\right\}$$

and calculates determinate forces of reaction $\{q_r\} = -\{P_r\} - [D^T]\{P_\ell\}$.

98. SSG4 calculates inertia loads and combines them with static loads

$$\{P_\ell^i\} = \{P_\ell\} + \Big([M_{\ell\ell}][D] + [M_{\ell r}]\Big)[m_r]^{-1}\{q_r\} \qquad \text{and}$$

$$\{P_o^i\} = \{P_o\} + \Big([M_{oo}][G_o] + [M_{ao}^T]\Big)\left[\frac{D}{I}\right][m_r]^{-1}\{q_r\} .$$

100. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell^i\} ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o^i\} ,$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell^i\} = \{P_\ell^i\} - [K_{\ell\ell}]\{u_\ell\}$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell^i\}}{\{P_\ell^i\}^T\{u_\ell\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o^i\} = \{P_o^i\} - [K_{oo}]\{u_o^o\},$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o^i\}}{\{P_o^i\}^T\{u_o^o\}} .$$

103. Go to DMAP No. 106 if residual vectors are not to be printed.

104. MATGPR prints residual the vector for independent coordinates (RULV).

105. MATGPR prints residual the vector for omitted coordinates (RUØV).

107. SDR1 recovers dependent displacements

$$\begin{Bmatrix} u_\ell \\ \hline u_r \end{Bmatrix} = \{u_a\}, \qquad \{u_o\} = [G_o]\{u_a\} + \{u_o^o\} ,$$

$$\begin{Bmatrix} u_a \\ \hline u_o \end{Bmatrix} = \{u_f\} , \qquad \begin{Bmatrix} u_f \\ \hline Y_s \end{Bmatrix} = \{u_n\},$$

$$\{u_m\} = [G_m]\{u_n\} , \qquad \begin{Bmatrix} u_n \\ \hline u_m \end{Bmatrix} = \{u_g\}$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\} .$$

109. Go to DMAP No. 114 if all constraint sets have been processed.

110. Go to DMAP No. 53 if additional sets of constraints need to be processed.

111. Go to DMAP No. 133 and print error message if number of loops exceeds 360.

113. Go to DMAP No. 139 and print error message if multiple boundary conditions are attempted with improper subset.

116. Go to DMAP No. 120 if no multi-point constraint force balance is requested.

117. EQMCK calculates the force and moment equilibrium check and prepares the multi-point constraint force balance (ØQM1) for output.

118. ØFP formats tables prepared by EQMCK and places them on the system output file for printing.

121. SDR2 calculates element forces (ØEF1) and stresses (ØES1) and prepares load vectors (ØPG1), displacement vectors (ØUGV1), and single-point forces of constraint (ØQG1) for output and translation components of the displacement vector (PUGV1).

123. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

125. Go to DMAP No. 129 if no deformed structure plots are requested.

126. PLØT generates all requested deformed structure and contour plots.

128. PRTMSG prints plotter data, engineering data, and contour data for each deformed plot generated.

130. Go to DMAP No. 141 and make normal exit.

132. STATIC ANALYSIS WITH INERTIA RELIEF ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR CALCULATIØN ØF INERTIA LØADS.

134. STATIC ANALYSIS WITH INERTIA RELIEF ERRØR MESSAGE NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 360 LØØPS.

136. STATIC ANALYSIS WITH INERTIA RELIEF ERRØR MESSAGE NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

138. STATIC ANALYSIS WITH INERTIA RELIEF ERRØR MESSAGE NØ. 4 - FREE-BØDY SUPPØRTS ARE REQUIRED.

140. STATIC ANALYSIS WITH INERTIA RELIEF ERRØR MESSAGE NØ. 5 - A LØØPING PRØBLEM RUN ØN A NØN-LØØPING SUBSET.

3.3.3 Case Control Deck and Parameters for Static Analysis with Inertia Relief

The following items relate to subcase definition and data selection for Static Analysis with Inertia Relief:

1. A separate subcase must be defined for each unique combination of constraints and static loads.
2. A static loading condition must be defined for (not necessarily within) each subcase with a LØAD selection.
3. An SPC set may be selected only if used to remove grid point singularities or some, but not all, of the free body motions. At least one free body support must be provided with a SUPØRT card in the Bulk Data Deck.
4. Loading conditions associated with the same sets of constraints should be in contiguous subcases in order to avoid unnecessary looping.
5. REPCASE may be used to repeat subcases in order to allow multiple sets for the same output item.

The following output may be requested for Static Analysis with Inertia Relief:

1. Displacements at selected grid points due to the sum of the applied loads and the inertia loads.
2. Nonzero components of the applied static loads at selected grid points.
3. Reactions on free-body supports due to applied loads (single-point forces of constraint).
4. Forces and stresses in selected elements due to the sum of the applied loads and inertia loads.
5. Undeformed and deformed plots of the structural model.
6. Contour plots of stress and displacement.

The following parameters are used in Static Analysis with Inertia Relief:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.
2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in EMA.

3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.

4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

5. ØPT - optional in static and normal modes analyses (rigid formats 1, 2, 3, 14, and 15). A positive integer value of this parameter causes both equilibrium and multipoint constraint forces to be calculated for the Case Control output request, MPCFØRCE. A negative integer value of this parameter causes only the equilibrium force balance to be calculated for the output request. The default value is 0 which causes only the multipoint constraint forces to be calculated for the output request.

6. GRDEQ - optional in static and normal modes analyses (rigid formats 1, 2, 3, 14, and 15). A positive integer value of this parameter selects the grid point about which equilibrium will be checked for the Case Control output request, MPCFØRCE. If the integer value is zero, the basic origin is used. Default is -1.

3.3.4 Automatic Alters for Automated Multi-stage Substructuring

The following lines of the Static Analysis with Inertia Relief, Rigid Format 2, are altered in automatic substructure analyses.

Phase 1: 2, 57, 86-93, 96-124

Phase 2: 2, 3-4, 8-21, 26, 38, 45-48, 60-65, 116-124

Phase 3: 86-93, 96-106, 108

If APP DISP,SUBS is used, the user may also specify ALTER's. However, these must not interfere with the automatically generated DMAP statement ALTER's listed above. See Section 5.9 for a description and listing of the ALTER's which are automatically generated for substructuring.

3.4 NORMAL MODE ANALYSIS

3.4.1 DMAP Sequence for Normal Mode Analysis

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 3

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN    NO.3 NORMAL MODES ANALYSIS - SERIES P $
    2  FILE     LAMA=APPEND/PHIA=APPEND $
    3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT $
    4  SAVE     LUSET $
    5  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $
    6  GP2      GEOM2,EQEXIN/ECT $
    7  CHKPNT   ECT $
    8  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
    9  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $
   10  COND     P1,NOPCDB $
   11  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/  V,N,
                JUMPPLOT=-1 $
   12  SAVE     NSIL,JUMPPLOT $
   13  PRTMSG   PLTSETX// $
   14  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $
   15  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $
   16  COND     P1,JUMPPLOT $
   17  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
   18  SAVE     JUMPPLOT,PLTFLG,PFILE $


   19  PRTMSG   PLOTX1//$
   20  LABEL    P1 $
   21  CHKPNT   PLTPAR,GPSETS,ELSETS $
   22  GP3      GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $
   23  CHKPNT   GPTT $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 3

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


24  TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,,/V,N,LUSET/V,N,
              NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

25  SAVE      NOGENL,NOSIMP,GENEL $

26  COND      ERROR1,NOSIMP $

27  PURGE     OGPST/GENEL $

28  CHKPNT    EST,GPECT,GEI,OGPST $

29  PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

30  PARAM     //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

31  EMG       EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
              N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
              CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
              CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

32  SAVE      NOKGGX,NOMGG $

33  CHKPNT    KELM,KDICT,MELM,MDICT $

34  COND      JMPKGG,NOKGGX $

35  EMA       GPECT,KDICT,KELM/KGGX,GPST $

36  CHKPNT    KGGX,GPST $

37  LABEL     JMPKGG $

38  COND      ERROR1,NOMGG $

39  EMA       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

40  CHKPNT    MGG $

41  COND      LGPWG,GRDPNT $


42  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $

43  OFP       OGPWG,,,,,// $

44  LABEL     LGPWG $

45  EQUIV     KGGX,KGG/NOGENL $

46  CHKPNT    KGG $

47  COND      LBL11,NOGENL $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 3

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


48  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
49  CHKPNT   KGG $
50  LABEL    LBL11 $
51  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
52  GP4      CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N,LUSET/
             V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
             N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
53  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $
54  COND     ERROR3,NOL $
55  PURGE    KRR,KLR,DM,MLR,MR/REACT/GM/MPCF1/GO/OMIT/KFS/SINGLE/QG/NOSET $
56  CHKPNT   KRR,KLR,DM,MLR,MR,GM,RG,GO,KFS,QG,USET,ASET $
57  COND     LBL4,GENEL $
58  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
59  SAVE     NOGPST $
60  COND     LBL4,NOGPST $
61  OFP      OGPST,,,,,// $
62  LABEL    LBL4 $
63  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1 $
64  CHKPNT   KNN,MNN $
65  COND     LBL2,MPCF2 $
66  MCE1     USET,RG/GM $

67  CHKPNT   GM $
68  MCE2     USET,GM,KGG,MGG,,/KNN,MNN,, $
69  CHKPNT   KNN,MNN $
70  LABEL    LBL2 $
71  EQUIV    KNN,KFF/SINGLE/MNN,MFF/SINGLE $
72  CHKPNT   KFF,MFF $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 3

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


73  COND      LBL3,SINGLE $
74  SCF1      USET,KNN,MNN,,/KFF,KFS,,MFF,, $
75  CHKPNT    KFS,KFF,MFF $
76  LABEL     LBL3 $
77  EQUIV     KFF,KAA/OMIT $
78  EQUIV     MFF,MAA/OMIT $
79  CHKPNT    KAA,MAA $
80  COND      LBL5,OMIT $
81  SMP1      USET,KFF,,,,/GO,KAA,KOO,LOO,,,,, $
82  CHKPNT    GO,KAA $
83  SMP2      USET,GO,MFF/MAA $
84  CHKPNT    MAA $
85  LABEL     LBL5 $
86  COND      LBL6,RFACT $
87  RBMG1     USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $
88  CHKPNT    KLL,KLR,KRR,MLL,MLR,MRR $
89  RBMG2     KLL/LLL $
90  CHKPNT    LLL $
91  RBMG3     LLL,KLR,KRR/DM $
92  CHKPNT    DM $

93  RBMG4     DM,MLL,MLR,MRR/MR $
94  CHKPNT    MR $
95  LABEL     LBL6 $
96  DPD       DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,,,,,,,EED,EQDYN/V,N,
              LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/   V,
              N,NONLFT/V,N,NOTRL/V,N,NOFED/C,N,/V,N,NOUE $
97  SAVE      NOFED $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 3

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


 98  COND      ERROR2,NOEED $
 99  CHKPNT    EED $
100  PARAM     //C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 $
101  READ      KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N,
               NEIGV $
102  SAVE      NEIGV $
103  CHKPNT    LAMA,PHIA,MI,OEIGS $
104  PARAM     //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
105  OFP       OEIGS,,,,,//V,N,CARDNO $
106  SAVE      CARDNO $
107  COND      FINIS,NEIGV $
108  OFP       LAMA,,,,,//V,N,CARDNO $
109  SAVE      CARDNO $
110  SDR1      USET,,PHIA,,,GO,GM,,KFS,,/PHIG,,QG/C,N,1/C,N,REIG $
111  CHKPNT    PHIG,QG $
112  COND      NOMPCF,GRDEQ $
113  EQMCK     CASECC,EQEXIN,GPL,BGPDT,SIL,USET,KGG,GM,PHIG,LAMA,QG,CSTM/OQM1/
               V,Y,OPT=0/V,Y,GRDEQ/C,N,-1 $
114  OFP       OQM1,,,,,//V,N,CARDNO $
115  SAVE      CARDNO $
116  LABEL     NOMPCF $


117  PARAM     //C,N,MPY/V,N,SIXSIL/V,N,NSIL/C,N,6 $
118  PARAM     //C,N,EQ /V,N,SCALAR/V,N,SIXSIL/V,N,LUSET $
119  EQUIV     SIL,SIP/SCALAR/BGPDT,BGPDP/SCALAR $
120  CHKPNT    SIP,BGPDP $
121  COND      LBL7,SCALAR $
122  PLTTRAN   BGPDT,SIL/BGPDP,SIP/V,N,LUSET/V,N,LUSEP $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 3

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


123  SAVE      LUSEP $
124  CHKPNT    BGPDP,SIP $
125  LABEL     LBL7 $
126  SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDP,LAMA,OG,PHIG,EST,,/ ,
               OOG1,OPHIG,OES1,OEF1,PPHIG/C,N,REIG $
127  OFP       OPHIG,OOG1,OEF1,OES1,,,//V,N,CARDNO $
128  SAVE      CARDNO $
129  COND      P2,JUMPPLOT $
130  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIP,,PPHIG,GPECT,OES1/
               PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
131  SAVE      PFILE $
132  PRTMSG    PLOTX2// $
133  LABEL     P2 $
134  JUMP      FINIS $
135  LABEL     ERROR1 $
136  PRTPARM   //C,N,-1/C,N,MODES $
137  LABEL     ERROR2 $
138  PRTPARM   //C,N,-2/C,N,MODES $
139  LABEL     ERROR3 $
140  PRTPARM   //C,N,-3/C,N,MODES $
141  LABEL     FINIS $


142  END       $
```

3.4.2 Description of DMAP Operations for Normal Mode Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot output is requested.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plots are requested.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Grid Point Temperature Table.

24. TA1 generates element tables for use in matrix assembly and stress recovery.

26. Go to DMAP No. 135 and print error message if there are no structural elements.

31. EMG generates structural element stiffness and mass matrix tables and dictionaries for later assembly.

34. Go to DMAP No. 37 if no stiffness matrix is to be assembled.

35. EMA assembles stiffness matrix $[K^{x}_{gg}]$ and Grid Point Singularity Table.

38. Go to DMAP No. 135 and print error message if no mass matrix exists.

39. EMA assembles mass matrix $[M_{gg}]$.

41. Go to DMAP No. 44 if no weight and balance is requested.

42. GPWG generates weight and balance information.

43. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

45. Equivalence $[K^{x}_{gg}]$ to $[K_{gg}]$ if no general elements.

47. Go to DMAP No. 50 if no general elements.

48. SMA3 adds general elements to stiffness matrix $[K^{x}_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

52. GP4 generates flags defining numbers of various displacement sets (USET) and forms multi-point constraint equations $[R_g]\{u_g\} = 0$.

54. Go to DMAP No. 139 and print error message if no independent degrees of freedom are defined.

57. Go to DMAP No. 62 if general elements present.

58. GPSP determines if possible grid point singularities remain.

60. Go to DMAP No. 62 if no Grid Point Singularity Table.

61. ØFP formats table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

63. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

65. Go to DMAP No. 70 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

66. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

68. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \quad \text{and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m].$$

71. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

73. Go to DMAP No. 76 if no single-point constraints.

74. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right].$$

77. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

78. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

80. Go to DMAP No. 85 if no omitted coordinates.

81. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

83. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o].$$

86. Go to DMAP No. 95 if no free-body supports.

87. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] \quad \text{and} \quad [M_{aa}] = \left[\begin{array}{c|c} M_{\ell\ell} & M_{\ell r} \\ \hline M_{r\ell} & M_{rr} \end{array}\right] .$$

89. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

91. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||} .$$

93. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

96. DPD extracts Eigenvalue Extraction Data from Dynamics data block.

98 Go to DMAP No. 137 and print error message if no Eigenvalue Extraction Data.

101. READ extracts real eigenvalues from the equation

$$[K_{aa} - \lambda M_{aa}]\{u_a\} = 0 \quad ,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized, computes rigid body eigenvectors

$$[\phi_{ao}] = \left[\begin{array}{c} D\ \phi_{ro} \\ \hline \phi_{ro} \end{array}\right] \quad ,$$

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass.

105. ØFP formats the summary of eigenvalue extraction information (ØEIGS) prepared by READ and places it on the system output file for printing.

107. Go to DMAP No. 141 and make normal exit if no eigenvalues found.

108. ØFP formats eigenvalues (LAMA) prepared by READ and places them on the system output file for printing.

110. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o]\{\phi_a\} \quad , \qquad \left\{\begin{array}{c}\phi_a \\ \hline \phi_o\end{array}\right\} = \{\phi_f\} \quad ,$$

$$\left\{\begin{array}{c}\phi_f \\ \hline \phi_s\end{array}\right\} = \{\phi_n\} \quad , \qquad \{\phi_m\} = [G_m]\{\phi_n\} \quad ,$$

$$\left\{\begin{array}{c}\phi_n \\ \hline \phi_m\end{array}\right\} = \{\phi_g\}$$

and recovers single-point forces of constraint $\{q_s\} = [K_{fs}]^T\{\phi_f\}$.

112. Go to DMAP No. 116 if no multi-point constraint force balance is requested.

113. EQMCK calculates the force and moment equilibrium check and prepares the multi-point constraint force balance (ØQM1) for output.

114. ØFP formats tables prepared by EQMCK and places them on the system output file for printing.

119. Equivalence SIL to SIP and BGPDT to BGPDP when one or more geometric grid points exist.

121. Go to DMAP No. 125 if no scalar points.

122. PLTTRAN modifies BGPDT and SIL for functional modules SDR2 and PLØT.

126. SDR2 calculates element forces (ØEF1) and stresses (ØES1) and prepares eigenvectors (ØPHIG) and single-point forces of constraint (ØQG1) for output and translation components of the eigenvectors (PPHIG).

127. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

129. Go to DMAP No. 133 if no deformed structure plots are requested.

130. PLØT generates all requested deformed structure and contour plots.

132. PRTMSG prints plotter data, engineering data, and contour data for each deformed plot generated.

134. Go to DMAP No. 144 and make normal exit.

136. NØRMAL MØDE ANALYSIS ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR REAL EIGENVALUE ANALYSIS.

138. NØRMAL MØDE ANALYSIS ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

140. NØRMAL MØDE ANALYSIS ERRØR MESSAGE NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

3.4.3 Automatic Output for Normal Mode Analysis

Each eigenvalue is identified with a mode number determined by sorting the eigenvalues by their magnitude. The following summary of the eigenvalues extracted is automatically printed:

1. Mode Number
2. Extraction Order
3. Eigenvalue
4. Radian Frequency
5. Cyclic Frequency
6. Generalized Mass
7. Generalized Stiffness

The following summary of the eigenvalue analysis performed, using the Inverse Power method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of starting points used.
3. Number of starting point moves.
4. Number of triangular decompositions.
5. Number of vector iterations.
6. Reason for termination.
 (1) Two consecutive singularities encountered while performing triangular decomposition.
 (2) Four shift points while tracking a single root.
 (3) All eigenvalues found in the frequency range specified.
 (4) Three times the number of roots estimated in the frequency range have been extracted.
 (5) All eigenvalues that exist in the problem have been found.
 (6) The number of roots desired have been found.
 (7) One or more eigenvalues have been found outside the frequency range specified.
 (8) Insufficient time to find another root.
 (9) Unable to converge
7. Largest off-diagonal modal mass term and the number failing the criteria.

The following summary of the eigenvalue analysis performed, using the Determinant method, is automatically printed:

4. ØPT - optional in static and normal modes analyses (rigid formats 1, 2, 3, 14, and 15). A positive integer value of this parameter causes both equilibrium and multipoint constraint forces to be calculated for the Case Control output request, MPCFØRCE. A negative integer value of this parameter causes only the equilibrium force balance to be calculated for the output request. The default value is 0 which causes only the multipoint constraint forces to be calculated for the output request.

5. GRDEQ - optional in static and normal modes analyses (rigid formats 1, 2, 3, 14, and 15). A positive integer value of this parameter selects the grid point about which equilibrium will be checked for the Case Control output request, MPCFØRCE. If the integer value is zero, the basic origin is used. Default is -1.

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY.

3.4.5 Automatic Alters for Automated Multi-stage Substructuring

The following lines of the Normal Modes Analysis, Rigid Format 3, are altered in automatic substructure analyses.

Phase 1: 2, 53, 86-95, 96-126

Phase 2: 2, 3-4, 10-21, 26, 38, 45-48, 57-62, 119-126

Phase 3: 86-95, 96-107, 108

If APP DISP,SUBS is used, the user may also specify ALTER's. However, these must not interfere with the automatically generated DMAP statement ALTER's listed above. See Section 5.9 for a description and listing of the ALTER's which are automatically generated for substructuring.

3.4.6 Optional Diagnostic Output for FEER

Special detailed information related to the generation of the reduced problem size, the elements of the reduced tridiagonal matrix, computed error bounds and other numerical tests can be obtained by requesting DIAG 16 in the NASTRAN Executive Control Deck.

The meaning of this information is explained below in the order in which it appears in the DIAG 16 output.

ØRDER - The order of the unreduced problem (size of the $[K_{aa}]$ matrix)

MAX RANK - The maximum number of existing finite eigensolutions as initially detected by FEER

RED ØRDER - The order of the reduced eigenproblem which will be solved to obtain the number of accurate solutions requested by the user

ØRTH VCT - The number of previously computed accurate eigenvectors on the eigenvector file which were generated prior to a restart or by the NASTRAN rigid body mode generator

USER SHIFT - The user specified shift after conversion from cycles to radians - squared (used only in frequency problems).

INTERNAL SHIFT- A small positive value automatically computed to remove singularities if the user has specified a zero shift. Otherwise, the negative of the user shift (used only in frequency problems).

SINGULARITY CHECK - PASS: the shifted stiffness matrix is non-singular
- ****: the number of internal shifts needed to remove stiffness matrix singularities

TRIDIAGONAL ELEMENTS ROW j, **, ***, **** - The computed tridiagonal elements of the reduced eigenmatrix:
j - Matrix row
** - Diagonal element
*** - Off-diagonal element
**** - First estimate of off-diagonal element in the next row

ØRTH ITER - The number of times a reorthogonalization of a trial vector has been performed

MAX PRØJ - The maximum projection of the above trial vector on the previously computed accurate trial vectors (prior to the current reorthogonalization)

NØRMAL FACT - The normalization factor for the reorthogonalized trial vector

ØPEN CØRE NØT USED *** FEER3 - Open core not used by Subroutine FEER3, in single-precision words

FEER QRW ELEMENT *, ITER **, ***, RATIØ ****, PRØJ *****:

* - The internal eigenvalue number in the order of its extraction by FEER

** - The number of inverse power iterations performed to extract the associated eigenvector of the reduced system (this is not a physical eigenvector)

*** - If a multiple root has been detected, the number of times that the previous multiple-root, reduced-system eigenvectors have been projected out of the current multiple-root eigenvector before repeating the inverse power iterations

**** - The absolute ratio of maximum, reduced-system eigenvector elements for successive inverse power iterations

***** - The maximum projection of a current multiple-root eigenvector on previously computed eigenvectors for the same root

PHYSICAL EIGENVALUE *, **, THEØR ERRØR *** PERCENT, PASS ØR FAIL:

* - The internal eigenvalue number in the order of its extraction by FEER

** - The associated physical eigenvalue (λ for buckling problems, ω^2 for frequency problems)

*** - Theoretical upper bound on the relative eigenvalue error

PASS - The computed error is less than or equal to the allowable specified on the EIGB or EIGR bulk data card (default is .001/n where n is the order of the stiffness matrix)

FAIL - The computed error is greater than the allowable and this mode is not accepted for further processing

ØPEN CØRE NØT USED *** FEER4 - Open core not used by Subroutine FEER4, in single precision words

FEER CØMPLETE *, **, ***, ****

* - The remaining CPU time available following decomposition of the shifted stiffness matrix, in seconds (the total time is specified on the TIME card in the Executive Control Deck)

** - The remaining CPU time, in seconds after completing Subroutine FEER3

*** - The remaining CPU time, in seconds after completing Subroutine FEER4

**** - The total operation count for FEER after decomposition of the shifted stiffness matrix. One operation is considered to be a multiplication or division followed by an addition

3.4.7 The APPEND Feature

In real eigenvalue analysis, it is frequently necessary to add new eigenvalues and eigenvectors to those already computed in a previous run. The APPEND feature (see Section 9.2.2 of the Theoretical Manual for details) makes it possible to do this without re-executing the entire problem. It is available when using the Inverse Power, Determinant and Tridiagonal Reduction (FEER) methods of eigenvalue extraction.

In order to use the APPEND feature, the user should employ the following steps:

1. Request a checkpoint of an eigenvalue problem by employing either the Inverse Power, Determinant or Tridiagonal Reduction (FEER) method.
2. Check to ensure that at least one eigenvalue and one eigenvector are computed in this run and that the LAMA (eigenvalue) and PHIA (eigenvector) files are successfully checkpointed.
3. Restart the problem by changing either the METHØD card in the Case Control Deck and/or the EIGR card in the Bulk Data Deck and ensuring that the following conditions are satisfied:
 a. The structural model and the constraint data for the restart must be the same as that used in the checkpoint run.
 b. The method of eigenvalue extraction employed in the restart need not be the same as that used in the checkpoint run, but the range of eigenvalues specified on the EIGR Bulk Data card should not include the eigenvalues already checkpointed in Step 1.
 c. If the user wishes to retrieve only a subset of the checkpointed eigenvalues and eigenvectors, a DMAP alter should be employed in the Executive Control Deck to reset the parameter NEIGV to the desired value by means of a PARAM statement just before the READ module in the DMAP sequence. (See Section 9.2.2 of the Theoretical Manual for details).
4. Note that the eigenvalues and eigenvectors output by the restart include those retrieved from the checkpointed run of Step 1. Also, the resulting eigenvectors are normalized according to the method of normalization specified in the restart.

3.5 STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS

3.5.1 DMAP Sequence for Static Analysis with Differential Stiffness

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 4

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


PTTONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

   1  BEGIN    NO.4 DIFFERENTIAL STIFFNESS ANALYSIS - SERIES P $
   2  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
               NOGPDT $
   3  SAVE     LUSET,NOGPDT $
   4  COND     ERROR1,NOGPDT $
   5  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $
   6  GP2      GEOM2,EQEXIN/ECT $
   7  CHKPNT   ECT $
   8  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
   9  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $
  10  COND     P1,NOPCDB $
  11  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/  V,N,
               JUMPPLOT=-1 $
  12  SAVE     NSIL,JUMPPLOT $
  13  PRTMSG   PLTSETX// $
  14  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $
  15  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $
  16  COND     P1,JUMPPLOT $
  17  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
               NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
  18  SAVE     JUMPPLOT,PLTFLG,PFILE $


  19  PRTMSG   PLOTX1// $
  20  LABEL    P1 $
  21  CHKPNT   PLTPAR,GPSETS,ELSETS $
  22  GP3      GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $
  23  SAVE     NOGRAV $
```

```
RIGID FORMAT DMAP LISTING
SERIES 9

DISPLACEMENT APPROACH, RIGID FORMAT 4

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


24  PARAM     //C,N,AND/V,N,NOMGG/V,N,NOGRAV/V,Y,GRDPNT=-1 $

25  CHKPNT    SLT,GPTT $

26  TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,,,/V,N,LUSET/V,N,
              NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

27  SAVE      NOSIMP,NOGENL,GENEL $

28  COND      ERROR1,NOSIMP $

29  PURGE     OGPST/GENEL $

30  CHKPNT    EST,GPECT,GEI,OGPST $

31  PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

32  EMG       EST,CSTM,MPT,DIT,GEOM2,,/KELM,KDICT,MELM,MDICT,,,/V,N,NOKGGX/ V,
              N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
              CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
              CPODPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

33  SAVE      NOKGGX,NOMGG $

34  CHKPNT    KELM,KDICT,MELM,MDICT $

35  COND      JMPKGG,NOKGGX $

36  EMA       GPECT,KDICT,KELM/KGGX,GPST $

37  CHKPNT    KGGX,GPST $

38  LABEL     JMPKGG $

39  COND      JMPMGG,NOMGG $

40  EMA       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

41  CHKPNT    MGG $


42  LABEL     JMPMGG $

43  COND      LBL1,GRDPNT $

44  COND      ERROR4,NOMGG $

45  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS $

46  OFP       OGPWG,,,,,// $

47  LABEL     LBL1 $
```

```
RIGID FORMAT DMAP LISTING
SERIES 8

DISPLACEMENT APPROACH, RIGID FORMAT 4

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


48  EQUIV     KGGX,KGG/NOGENL $

49  CHKPNT    KGG $

50  COND      LBL11,NOGENL $

51  SMA3      GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

52  CHKPNT    KGG $

53  LABEL     LBL11 $

54  PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

55  CASE      CASECC,/CASEXX/C,N,TRANRESP/C,N,0/V,N,NOLOOP $

56  GP4       CASEXX,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N,LUSET/
              V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
              N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

57  SAVE      MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

58  COND      ERROR5,NOL $

59  PURGE     GM/MPCF1/GO,KOO,LOO,PO,UOOV,PUOV/OMIT/PS,KFS,KSS,QG/SINGLE/
              UBOOV/OMIT/YBS,PBS,KBFS,KBSS,KDFS,KDSS/SINGLE $

60  CHKPNT    GM,RG,GO,KOO,LOO,PO,UOOV,RUOV,YS,PS,KFS,KSS,USET,ASET,  UBOOV,
              YBS,PBS,KBFS,KBSS,KDFS,KDSS,QG $

61  COND      LBL4D,REACT $

62  JUMP      ERROR2 $

63  LABEL     LBL4D $

64  COND      LBL4,GENFL$

65  GPSP      GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $


66  SAVE      NOGPST $

67  COND      LBL4,NOGPST $

68  OFP       OGPST,,,,,// $

69  LABEL     LBL4 $

70  EQUIV     KGG,KNN/MPCF1 $

71  CHKPNT    KNN $
```

```
RIGID FORMAT DMAP LISTING
SERIES P .

DISPLACEMENT APPROACH, RIGID FORMAT 4

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


72  COND      LBL2,MPCF2 $
73  MCE1      USET,RG/GM $
74  CHKPNT    GM $
75  MCE2      USET,GM,KGG,,,,/KNN,,, $
76  CHKPNT    KNN $
77  LABEL     LBL2 $
78  EQUIV     KNN,KFF/SINGLE $
79  CHKPNT    KFF $
80  COND      LBL3,SINGLE $
81  SCE1      USET,KNN,,,,/KFF,KFS,KSS,,, $
82  CHKPNT    KFS,KSS,KFF $
83  LABEL     LBL3 $
84  EQUIV     KFF,KAA/OMIT $
85  CHKPNT    KAA $
86  COND      LBL5,OMIT $
87  SMP1      USET,KFF,,,,/GO,KAA,KOO,LOO,,,,, $
88  CHKPNT    GO,KAA,KOO,LOO $
89  LABEL     LBL5 $
90  RBMG2     KAA/LLL $
91  CHKPNT    LLL $


92  SSG1      SLT,BGPDT,CSTM,SIL,EST,MPT,GPTT,EQT,MGG,CASEXX,DIT/PG/V,N,
              LUSET/C,N,1 $
93  CHKPNT    PG $
94  EQUIV     PG,PL/NOSET $
95  CHKPNT    PL $
96  COND      LBL10,NOSET $
97  SSG2      USET,GM,YS,KFS,GO,,PG/,PO,PS,PL $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 4

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


 98  CHKPNT   PO,PS,PL $
 99  LABEL    LBL10 $
100  SSG3     LLL,KAA,PL,LOO,KOO,PO/ULV,UOOV,PULV,RUOV/V,N,OMIT/V,Y,IRES=-1/
              C,N,1/V,N,EPSI $
101  SAVE     EPSI $
102  CHKPNT   ULV,UOOV,RULV,RUOV $
103  COND     LBL9,IRES $
104  MATGPR   GPL,USET,SIL,RULV//C,N,L $
105  MATGPR   GPL,USET,SIL,RUOV//C,N,O $
106  LABEL    LBL9 $
107  SDR1     USET,,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,/UGV,PG1,OG/C,N,1/C,N,DSO $
108  CHKPNT   UGV,OG $
109  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,OG,UGV,EST,,PG/
              OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,DSO $
110  PARAM    //C,N,MPY/V,N,CARDNO/C,N,O/C,N,O $
111  OFP      OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $
112  SAVE     CARDNO $
113  COND     P2,JUMPPLOT $
114  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,,GPECT,OES1/
              PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
115  SAVE     PFILE $
116  PRTMSG   PLOTX2// $


117  LABEL    P2 $
118  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/X1,X2,X3,ECPT,GPCT/V,N,LUSET/   V,
              N,NOSIMP/C,N,O/V,N,NOGENL/V,N,GENFL $
119  DSMG1    CASECC,GPTT,SIL,EDT,UGV,CSTM,MPT,ECPT,GPCT,DIT/KDGG/   V,N,
              DSCOSET$
120  CHKPNT   KDGG $
121  PARAM    //C,N,ADD/V,N,SHIFT/C,N,-1/C,N,O $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 4

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


122  PARAM     //C,N,ADD/V,N,COUNT/V,N,ALWAYS=-1/V,N,NEVER= 1 $
123  PARAMD    //C,N,ADD/V,N,DSEPSI/C,N,0.0/C,N,0.0 $
124  PARAML    YS//C,N,NULL/C,N,/C,N,/C,N,/V,N,NOYS $
125  JUMP      OUTLPTOP $
                                                    Top of Stiffness Adjustment Loop
126  LABEL     OUTLPTOP $
127  EQUIV     PG,PG1/NOYS $
128  CHKPNT    PG1 $
129  PARAM     //C,N,KLOCK/V,N,TO $
130  EQUIV     KDGG,KDNN/MPCF2 $
131  CHKPNT    KDNN $
132  COND      LBL2D,MPCF2 $
133  MCE2      USET,GM,KDGG,,,,/KDNN,,, $
134  CHKPNT    KDNN $
135  LABEL     LBL2D $
136  EQUIV     KDNN,KDFF/SINGLE $
137  CHKPNT    KDFF $
138  COND      LBL3D,SINGLE $
139  SCE1      USET,KDNN,,,,/KDFF,KDFS,KDSS,,, $
140  CHKPNT    KDFF,KDFS,KDSS $
141  LABEL     LBL3D $

142  EQUIV     KDFF,KDAA/OMIT $
143  CHKPNT    KDAA $
144  COND      LBL5D,OMIT $
145  SMP2      USET,SG,KDFF/KDAA $
146  CHKPNT    KDAA $
147  LABEL     LBL5D $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 4

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


148  ADD       KAA,KDAA/KBLL $
149  ADD       KFS,KDFS/KBFS $
150  ADD       KSS,KDSS/KBSS $
151  COND      PGDK,NOYS $
152  MPYAD     KBSS,YS,/PSS/C,N,0/C,N,1/C,N,1/C,N,1 $
153  MPYAD     KBFS,YS,/PFS/C,N,0/C,N,1/C,N,1/C,N,1 $
154  UMERGE    USET,PFS,PSS/PN/C,N,N/C,N,F/C,N,S $
155  EQUIV     PN,PGX/MPCF2 $
156  COND      LBL6D,MPCF2 $
157  UMERGE    USET,PN,/PGX/C,N,G/C,N,N/C,N,M $
158  LABEL     LBL6D $
159  ADD       PGX,PG/PGG/C,N,(-1.0,0.0) $
160  EQUIV     PGG,PG1/ALWAYS $
161  LABEL     PGDK $
162  ADD       PG1,/PGO/ $
163  (PRMG2)   KBLL/LBLL/V,N,POWER/V,N,DET
164  SAVE      DET,POWER $
165  CHKPNT    LBLL $
166  PRTPARM   //C,N,0/C,N,DET $
167  PRTPARM   //C,N,0/C,N,POWER $

168  JUMP      INLPTOP $                    ( Top of Load Correction Loop )
169  LABEL     INLPTOP $
170  PARAM     //C,N,KLOCK/V,N,TI $
171  (SSG2)    USET,GM,YS,KDFS,GO,,PG1/,PBO,PRS,PBL $
172  (SSG3)    LBLL,KBLL,PBL,,,,/UBLV,,PUBLV,/C,N,-1/V,Y,IRES/V,N,NOSKIP/V,N,
               EPSI $
173  SAVE      EPSI $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 4

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


174  CHKPNT   UBLV,RUBLV $
175  COND     LBL9D,IRES $
176  MATGPR   GPL,USET,SIL,RUBLV//C,N,L $
177  LABEL    LBL9D $
178  SDR1     USET,,UBLV,,YS,GO,GM,PBS,KBFS,KBSS,/UBGV,,OBG/C,N,1/C,N,DS1 $
179  CHKPNT   UBGV,OBG $
180  ADD      UBGV,UGV/DUGV/C,N,(-1.0,0.0) $
181  DSMG1    CASECC,GPTT,SIL,EDT,DUGV,CSTM,MPT,ECPT,GPCT,DIT/DKDGG/V,N,
              DSCOSET $
182  CHKPNT   DKDGG $
183  MPYAD    DKDGG,UBGV,PG0/PGI1/C,N,0/C,N,1/C,N,1/C,N,0 $
184  DSCHK    PG1,PGI1,UBGV//C,Y,EPSI0=1.E-5/V,N,DSEPSI/C,Y,NT=10/V,N,I0/V,N,
              II/V,N,DONE/V,N,SHIFT/V,N,COUNT/C,Y,BETAD=4 $
185  SAVE     DSEPSI,DONE,SHIFT,COUNT $
186  COND     DONE,DONE $
187  COND     SHIFT,SHIFT $
188  EQUIV    PG,PG1/NEVER $
189  EQUIV    PGI1,PG1/ALWAYS $
190  EQUIV    PG1,PGI1/NEVER $
191  REPT     INLPTOP,1000 $                    Bottom of Load Correction Loop
192  TABPT    PGI1,PG1,PG,,// $


193  LABEL    SHIFT $
194  ADD      DKDGG,KDGG/KDGG1/C,N,(-1.0,0.0) $
195  CHKPNT   KDGG1 $
196  EQUIV    UBGV,UGV/ALWAYS/KDGG1,KDGG/ALWAYS $
197  CHKPNT   KDGG $
198  EQUIV    KDGG,KDGG1/NEVER/UGV,UBGV/NEVER $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 4

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


199  REPT      OUTLPTOP,1000 $
200  TABPT     KDGG1,KDGG,UGV,,// $                    Bottom of Stiffness Adjustment Loop
201  LABEL     DONE $
202  CHKPNT    CSTM $
203  SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,OBG,UBGV,EST,,/
               ,OQBG1,OUBGV1,OESB1,OEFB1,PUBGV1/C,N,DS1 $
204  OFP       OUBGV1,OQBG1,OEFB1,OESB1,,//V,N,CARDNO $
205  SAVE      CARDNO $
206  COND      P3,JUMPPLOT $
207  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUBGV1,,GPECT,
               OESB1/PLOTX3/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,
               PFILE $
208  SAVE      PFILE $
209  PRTMSG    PLOTX3// $
210  LABEL     P3 $
211  JUMP      FINIS $
212  LABEL     ERROR1 $
213  PRTPARM   //C,N,-1/C,N,DIFFSTIF $
214  LABEL     ERROR2 $
215  PRTPARM   //C,N,-2/C,N,DIFFSTIF $
216  LABEL     ERROR4 $
217  PRTPARM   //C,N,-4/C,N,DIFFSTIF $

218  LABEL     ERROR5 $
219  PRTPARM   //C,N,-5/C,N,DIFFSTIF $
220  LABEL     FINIS $
221  END       $
```

3.5.2 Description of DMAP Operations for Static Analysis with Differential Stiffness

2. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

4. Go to DMAP No. 212 if no grid point definition table.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot output is requested.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plots are requested.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Static Loads Table and Grid Point Temperature Table.

26. TA1 generates element tables for use in matrix assembly and stress recovery.

28. Go to DMAP No. 212 and print error message if no structural elements.

32. EMG generates structural element stiffness and mass matrix tables and dictionaries for later assembly.

35. Go to DMAP No. 38 if no stiffness matrix is to be assembled.

36. EMA assembles stiffness matrix $[K^{x}_{gg}]$ and Grid Point Singularity Table.

39. Go to DMAP No. 42 if no mass matrix is to be assembled.

40. EMA assembles mass matrix $[M_{gg}]$.

43. Go to DMAP No. 47 if no weight and balance is requested.

44. Go to DMAP No. 216 and print error message if no mass matrix exists.

45. GPWG generates weight and balance information.

46. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

48. Equivalence $[K^{x}_{gg}]$ to $[K_{gg}]$ if no general elements.

50. Go to DMAP No. 53 if no general elements.

51. SMA3 adds general elements to $[K^{x}_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

56. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

58. Go to DMAP No. 218 and print error message if no independent degrees of freedom are defined.

61. Go to DMAP No. 63 if no free-body supports supplied.

64. Go to DMAP No. 69 if general elements present.

65. GPSP determines if possible grid point singularities remain.

67. Go to DMAP No. 69 if no Grid Point Singularity Table.

68. ØFP formats table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

70. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

72. Go to DMAP No. 77 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

73. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

75. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

78. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

80. Go to DMAP No. 83 if no single-point constraints.

81. SCE1 partitions out single-point constraints.

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right].$$

84. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

86. Go to DMAP No. 89 if no omitted coordinates.

87. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$
and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

90. RMBG2 decomposes constrained stiffness matrix $[K_{aa}] = [L_{\ell\ell}][U_{\ell\ell}]$

92. SSG1 generates static load vectors $\{P_g\}$.

94. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

96. Go to DMAP No. 99 if no constraints applied.

97. SSG2 applies constraints to static load vectors

$$\{P_g\} = \begin{Bmatrix} \bar{P}_n \\ \hline P_m \end{Bmatrix} , \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\} ,$$

$$\{P_n\} = \begin{Bmatrix} \bar{P}_f \\ \hline P_s \end{Bmatrix} , \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\} ,$$

$$\{P_f\} = \begin{Bmatrix} P_a \\ \hline P_o \end{Bmatrix} \quad \text{and} \quad \{P_\ell\} = \{P_a\} + [G_o^T]\{P_o\} .$$

100. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{aa}]^{-1}\{P_\ell\} ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\},$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{aa}]\{u_\ell\}$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\},$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o^o\}} .$$

103. Go to DMAP No. 106 if residual vectors are not to be printed.

104. MATGPR prints residual vector for independent coordinates (RULV).

105. MATGPR prints residual vector for omitted coordinates (RUØV).

107. SDR1 recovers dependent displacements

$$\{u_o\} = [G_o]\{u_\ell\} + \{u_o^o\} \quad ,$$

$$\left\{\begin{matrix} u_a \\ \hline u_o \end{matrix}\right\} = \{u_f\} \quad , \qquad \left\{\begin{matrix} u_f \\ \hline Y_s \end{matrix}\right\} = \{u_n\} \quad ,$$

$$\{u_m\} = [G_m]\{u_n\}, \qquad \left\{\begin{matrix} u_n \\ \hline u_m \end{matrix}\right\} = \{u_g\} \quad ,$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\} \quad .$$

109. SDR2 calculates element forces (ØEF1) and stresses (ØES1) and prepares load vectors (ØPG1), displacement vectors (ØUGV1) and single-point forces of constraint (ØQG1) for output and translation components of the displacement vector (PUGV1) for the static solution.

111. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

113. Go to DMAP No. 117 if no deformed static solution structure plots are requested.

114. PLØT generates all requested static solution deformed structure and contour plots.

116. PRTMSG prints plotter data, engineering data, and contour data for each deformed static solution plot generated.

118. TA1 generates element tables for use in differential stiffness matrix assembly.

119. DSMG1 generates differential stiffness matrix $[K_{gg}^d]$.

125. Go to next DMAP instruction if cold start or modified restart. ØUTLPTØP will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

126. Beginning of outer (stiffness adjustment) loop for differential stiffness iteration.

127. Equivalence $\{P_g\}$ to $\{P_{g1}\}$ if no enforced displacements.

130. Equivalence $[K_{gg}^d]$ to $[K_{nn}^d]$ if no multipoint constraints.

132. Go to DMAP No. 135 if no multipoint constraints.

133. MCE2 partitions differential stiffness matrix

$$[K_{gg}^d] = \left[\begin{matrix} \bar{K}_{nn}^d & K_{nm}^d \\ \hline K_{mn}^d & K_{mm}^d \end{matrix}\right]$$

and performs matrix reduction $[K_{nn}^d] = [\bar{K}_{nn}^d] + [G_m^T][K_{mn}^d] + [K_{mn}^d][G_m] + [G_m^T][K_{mm}^d][G_m]$.

136. Equivalence $[K^d_{nn}]$ to $[K^d_{ff}]$ if no single-point constraints.

138. Go to DMAP No. 141 if no single-point constraints.

139. SCE1 partitions out single-point constraints

$$[K^d_{nn}] = \left[\begin{array}{c|c} K^d_{ff} & K^d_{fs} \\ \hline K^d_{sf} & K^d_{ss} \end{array}\right].$$

142. Equivalence $[K^d_{ff}]$ to $[K^d_{aa}]$ if no omitted coordinates.

144. Go to DMAP No. 147 if no omitted coordinates.

145. SMP2 partitions constrained differential stiffness matrix

$$[K^d_{ff}] = \left[\begin{array}{c|c} \bar{K}^d_{aa} & K^d_{ao} \\ \hline K^d_{oa} & K^d_{oo} \end{array}\right]$$

and performs matrix reduction $[K^d_{aa}] = [\bar{K}^d_{aa}] + [K^d_{oa}]^T[G_o] + [G_o]^T[K^d_{oa}] + [G_o]^T[K^d_{oo}][G_o]$.

148. ADD $[K_{aa}]$ and $[K^d_{aa}]$ to form $[K^b_{\ell\ell}]$.

149. ADD $[K_{fs}]$ and $[K^d_{fs}]$ to form $[K^b_{fs}]$.

150. ADD $[K_{ss}]$ and $[K^d_{ss}]$ to form $[K^b_{ss}]$.

151. Go to DMAP No. 161 if no enforced displacements.

152. MPYAD multiplies $[K^b_{ss}]$ and $\{Y_s\}$ to form $\{P_{ss}\}$.

153. MPYAD multiplies $[K^b_{fs}]$ and $\{Y_s\}$ to form $\{P_{fs}\}$.

154. UMERGE combines $\{P_{fs}\}$ and $\{P_{ss}\}$ to form $\{P_n\}$.

155. Equivalence $\{P_n\}$ to $\{P^x_g\}$ if no multi-point constraints.

156. Go to DMAP No. 158 if no multi-point constraints.

157. UMERGE expands $\{P_n\}$ to form $\{P^x_g\}$.

159. ADD $-\{P^x_g\}$ and $\{P_g\}$ to form $\{P_{gg}\}$.

160. Equivalence $\{P_{gg}\}$ to $\{P_{g1}\}$.

162. ADD $\{P_{g1}\}$ and nothing to create $\{P_{go}\}$.

163. RBMG2 decomposes the combined differential stiffenss matrix and elastic stiffness matrix.

$$[K^b_{\ell\ell}] = [L^b_{\ell\ell}][U^b_{\ell\ell}].$$

166. PRTPARM prints the scaled value of the determinant of the combined differential stiffness matrix and elastic stiffness matrix.

167. PRTPARM prints the scale factor (power of ten) of the determinant of the combined differential stiffness matrix and the elastic stiffness matrix.

168. Go to next DMAP instruction if cold start or modified restart. INLPTØP will be altered by the executive system to the proper location inside the loop for unmodified restarts within the loop.

169. Beginning of inner (load correction) loop for differential stiffness iteration.

171. SSG2 applies constraints to static load vectors

$$\{P_{g1}\} = \begin{Bmatrix} \bar{P}^b_n \\ - \\ P^b_m \end{Bmatrix}, \qquad \{P^b_n\} = \{\bar{P}^b_n\} + [G^T_m]\{P^b_m\} ,$$

$$\{P^b_n\} = \begin{Bmatrix} \bar{P}^b_f \\ - \\ P^b_s \end{Bmatrix}, \qquad \{P_f\} = \{\bar{P}^b_f\} - [K^d_{fs}]\{Y_s\} ,$$

$$\{P^b_f\} = \begin{Bmatrix} P^b_a \\ - \\ P^b_o \end{Bmatrix} \quad \text{and} \quad \{P^b_\ell\} = \{P^b_a\} + [G^T_o]\{P^b_o\} .$$

172. SSG3 solves for displacements of independent coordinates for current differential stiffness load vector

$$\{u^b_\ell\} = [K^b_{\ell\ell}]^{-1}\{P^b_\ell\}$$

and calculates residual vector (RBULV) and residual vector error ratio for current differential stiffness load vector

$$\{\delta P^b_\ell\} = \{P^b_\ell\} - [K^b_{\ell\ell}]\{u^b_\ell\} ,$$

$$\varepsilon^b_\ell = \frac{\{u^b_\ell\}^T\{\delta P^b_\ell\}}{\{P^b_\ell\}^T\{u^b_\ell\}} .$$

175. Go to DMAP No. 177 if residual vector for current differential stiffness solution is not to be printed.

176. MATGPR prints residual vector for current differential stiffness solution.

178. SDR1 recovers dependent displacements for current differential stiffness solution

$$\{u_o^b\} = [G_o]\{u_\ell^b\} + \{u_o^{ob}\} \quad , \qquad \left\{\begin{matrix} u_\ell^b \\ \hline u_o^b \end{matrix}\right\} = \{u_f^b\} \quad ,$$

$$\left\{\begin{matrix} u_f^b \\ \hline Y_s^b \end{matrix}\right\} = \{u_n^b\} \quad , \qquad \{u_m^b\} = [G_m]\{u_n^b\} \quad ,$$

$$\left\{\begin{matrix} u_n^b \\ \hline u_m^b \end{matrix}\right\} = \{u_g^b\}$$

and recovers single-point forces of constraint for current differential stiffness solution

$$\{q_s^b\} = -\{P_s^b\} + [K_{sf}^b]\{u_f^b\} + [K_{ff}^b]\{Y_s^b\} \quad .$$

180. ADD $-\{U_g^b\}$ and $\{U_g\}$ to form $\{U_g^d\}$.

181. DSMG1 generates differential stiffness matrix $[\delta K_{gg}^d]$

183. MPYAD forms load vector for inner loop iteration.

$$\{P_{g_{I1}}\} = [\delta K_{gg}^d]\{U_g^b\} + \{P_{go}\}$$

184. DSCHK performs differential stiffness convergence checks.

186. Go to DMAP No. 201 if differential stiffness iteration is complete.

187. Go to DMAP No. 193 if additional differential stiffness matrix changes are necessary for further iteration.

188. Equivalence breaks previous equivalence of $\{P_g\}$ to $\{P_{g1}\}$.

189. Equivalence $\{P_{g_{I1}}\}$ to $\{P_{g1}\}$

190. Equivalence breaks previous equivalence of $\{P_{g1}\}$ to $\{P_{g_{I1}}\}$.

191. Go to DMAP No. 169 for additional inner loop differential stiffness iteration.

192. TABPT table prints vectors $\{P_{g_{I1}}\}$, $\{P_{g1}\}$, and $\{P_g\}$.

194. ADD $-[\delta K_{gg}^d]$ and $[K_{gg}^d]$ to form $[K_{gg1}^d]$.

196. Equivalence $\{U_g^b\}$ to $\{U_g\}$ and $[K_{gg1}^d]$ to $[K_{gg}^d]$.

3.6 BUCKLING ANALYSIS

3.6.1 DMAP Sequence for Buckling Analysis

```
RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 5

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN    NO.5 BUCKLING ANALYSIS - SERIES P $

    2  FILE     LAMA=APPEND/PHIA=APPEND $

    3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT $

    4  SAVE     LUSET $

    5  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

    6  GP2      GEOM2,EQEXIN/ECT $

    7  CHKPNT   ECT $

    8  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

    9  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

   10  COND     P1,NOPCDB $

   11  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/  V,N,
                JUMPPLOT=-1 $

   12  SAVE     NSIL,JUMPPLOT $

   13  PRTMSG   PLTSETX// $

   14  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

   15  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

   16  COND     P1,JUMPPLOT $

   17  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

   18  SAVE     JUMPPLOT,PLTFLG,PFILE $


   19  PRTMSG   PLOTX1// $

   20  LABEL    P1 $

   21  CHKPNT   PLTPAR,GPSETS,ELSETS $

   22  GP3      GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $

   23  SAVE     NOGRAV $
```

```
RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 5

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


24  PARAM     //C,N,AND/V,N,NOMGG/V,N,NOGRAV/V,Y,GRDPNT=-1 $
25  CHKPNT    SLT,GPTT $
26  TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,,,/V,N,LUSET/V,N,
              NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $
27  SAVE      NOSIMP,NOGENL,GENEL $
28  COND      ERROR1,NOSIMP $
29  PURGE     OGPST/GENEL $
30  CHKPNT    EST,GPECT,GEI,OGPST $
31  PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $
32  EMG       EST,CSTM,MPT,DIT,GEOM2,,/KELM,KDICT,MELM,MDICT,,,/V,N,NOKGGX/ V,
              N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
              CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
              CPODPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $
33  SAVE      NOKGGX,NOMGG $
34  CHKPNT    KELM,KDICT,MELM,MDICT $
35  COND      JMPKGG,NOKGGX $
36  EMA       GPECT,KDICT,KELM/KGGX,GPST $
37  CHKPNT    KGGX,GPST $
38  LABEL     JMPKGG $
39  COND      JMPMGG,NOMGG $
40  EMA       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $
41  CHKPNT    MGG $


42  LABEL     JMPMGG $
43  COND      LBL1,GRDPNT $
44  COND      ERROR5,NOMGG $
45  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS $
46  OFP       OGPWG,,,,,// $
47  LABEL     LBL1 $
```

```
RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 5

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


48  EQUIV     KGGX,KGG/NOGENL $
49  CHKPNT    KGG $
50  COND      LBL11,NOGENL $
51  SMA3      GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
52  CHKPNT    KGG $
53  LABEL     LBL11 $
54  PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
55  GP4       CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N,LUSET/
              V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
              N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
56  SAVE      MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $
57  COND      ERROR6,NOL $
58  PARAM     //C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT $
59  PURGE     GM/MPCF1/GO,KOO,LOO,PO,UOOV,RUOV/OMIT/PS,KFS,KSS/SINGLE/  QG/
              NOSR $
60  CHKPNT    GM,RG,GO,KOO,LOO,PO,UOOV,RUOV,YS,PS,KFS,KSS,USET,ASET,QG $
61  COND      LBL4D,REACT $
62  JUMP      ERROR2 $
63  LABEL     LBL4D $
64  COND      LBL4,GENFL $
65  GPSP      GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
66  SAVE      NOGPST $

67  COND      LBL4,NOGPST $
68  OFP       OGPST,,,,,// $
69  LABEL     LBL4 $
70  EQUIV     KGG,KNN/MPCF1 $
71  CHKPNT    KNN $
72  COND      LBL2,MPCF2 $
```

```
RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 5

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


73  MCE1    USET,RG/GM $
74  CHKPNT  GM $
75  MCE2    USET,GM,KGG,,,/KNN,,, $
76  CHKPNT  KNN $
77  LABEL   LBL2 $
78  EQUIV   KNN,KFF/SINGLE $
79  CHKPNT  KFF $
80  COND    LBL3,SINGLE $
81  SCE1    USET,KNN,,,/KFF,KFS,KSS,,, $
82  CHKPNT  KFS,KSS,KFF $
83  LABEL   LBL3 $
84  EQUIV   KFF,KAA/OMIT $
85  CHKPNT  KAA $
86  COND    LBL5,OMIT $
87  SMP1    USET,KFF,,,,/GO,KAA,KOO,LOO,,,,, $
88  CHKPNT  GO,KAA,KOO,LOO $
89  LABEL   LBL5 $
90  RBMG2   KAA/LLL $
91  CHKPNT  LLL $
92  SSG1    SLT,BGPDT,CSTM,SIL,EST,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/ V,N,
            LUSET/C,N,1 $

93  CHKPNT  PG $
94  EQUIV   PG,PL/NOSET $
95  CHKPNT  PL $
96  COND    LBL10,NOSET $
97  SSG2    USET,GM,YS,KFS,GO,,PG/,PO,PS,PL $
98  CHKPNT  PO,PS,PL $
```

```
RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 5

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


 99  LABEL    LBL10 $
100  SSG3     LLL,KAA,PL,L00,K00,PO/ULV,UOOV,RULV,RUOV/V,N,OMIT/V,Y,IRES=-1/
              C,N,1/V,N,EPSI $
101  SAVE     EPSI $
102  CHKPNT   ULV,UOOV,RULV,RUOV $
103  COND     LBL9,IRES $
104  MATGPR   GPL,USET,SIL,RULV//C,N,L $
105  MATGPR   GPL,USET,SIL,RUOV//C,N,O $
106  LABEL    LBL9 $
107  SDR1     USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,/UGV,PGG,QG/C,N,1/C,N,
              BKLO $
108  CHKPNT   UGV,QG,PGG $
109  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QG,UGV,EST,,PGG/
              OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,BKLO $
111  OFP      OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $
112  SAVE     CARDNO $
113  COND     P2,JUMPPLOT $
114  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,,GPECT,OES1/
              PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
115  SAVE     PFILE $
116  PRTMSG   PLOTX2// $
117  LABEL    P2 $


118  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/X1,X2,X3,ECPT,GPCT/V,N,LUSET/   V,
              N,NOSIMP/C,N,0/V,N,NOGENL/V,N,GENEL $
119  DSMG1    CASECC,GPTT,SIL,EDT,UGV,CSTM,MPT,ECPT,GPCT,DIT/KDGG/  V,N,
              DSCOSET $
120  CHKPNT   KDGG $
121  EQUIV    KDGG,KDNN/MPCF2 $
122  CHKPNT   KDNN $
```

```
RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 5

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


123  COND      LBL2D,MPCF2 $
124  MCE2      USET,GM,KDGG,,,/KDNN,,, $
125  CHKPNT    KDNN $
126  LABEL     LBL2D $
127  EQUIV     KDNN,KDFF/SINGLE $
128  CHKPNT    KDFF $
129  COND      LBL3D,SINGLE $
130  SCE1      USET,KDNN,,,/KDFF,KDFS,,,, $
131  CHKPNT    KDFF,KDFS $
132  LABEL     LBL3D $
133  EQUIV     KDFF,KDAA/OMIT $
134  CHKPNT    KDAA $
135  COND      LBL5D,OMIT $
136  SMP2      USET,GO,KDFF/KDAA $
137  CHKPNT    KDAA $
138  LABEL     LBL5D $
139  ADD       KDAA,/KDAAM/C,N,(-1.0,0.0)/C,N,(0.0,0.0) $
140  CHKPNT    KDAAM $
141  DPD       DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,,,,,,,EED,EQDYN/V,N,
               LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/  V,
               N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $


142  SAVE      NOEED $
143  COND      ERROR3,NOEED $
144  CHKPNT    EED $
145  PARAM     //C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 $
146  READ      KAA,KDAAM,,,EED,USET,CASECC/LAMA,PHIA,,OEIGS/C,N,BUCKLING/ V,N,
               NEIGV/C,N,2 $
147  SAVE      NEIGV $
```

```
RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 5

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


148  CHKPNT   LAMA,PHIA,OEIGS $
149  OFP      OEIGS,LAMA,,,,,//V,N,CARDNO $
150  SAVE     CARDNO $
151  COND     ERROR4,NEIGV $
152  SDR1     USET,,PHIA,,,GO,GM,,KFS,,/PHIG,,BQG/C,N,1/C,N,BKL1 $
153  CHKPNT   PHIG,BQG $
154  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDT,LAMA,BQG,PHIG,EST,,/,
              OBQG1,OPHIG,OBES1,OBEF1,PPHIG/C,N,BKL1 $
155  OFP      OPHIG,OBQG1,OBEF1,OBES1,,//V,N,CARDNO $
156  SAVE     CARDNO $
157  COND     P3,JUMPPLOT $
158  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,PPHIG,GPECT,
              OBES1/PLOTX3/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,
              PFILE $
159  SAVE     PFILE $
160  PRTMSG   PLOTX3// $
161  LABEL    P3 $
162  JUMP     FINIS $
163  LABEL    ERROR1 $
164  PRTPARM  //C,N,-1/C,N,BUCKLING $
165  LABEL    ERROR2 $
166  PRTPARM  //C,N,-2/C,N,BUCKLING $

167  LABEL    ERROR3 $
168  PRTPARM  //C,N,-3/C,N,BUCKLING $
169  LABEL    ERROR4 $
170  PRTPARM  //C,N,-4/C,N,BUCKLING $
171  LABEL    ERROR5 $
172  PRTPARM  //C,N,-5/C,N,BUCKLING $
```

```
RIGID FORMAT DMAP LISTING
SERIES 0.

DISPLACEMENT APPROACH, RIGID FORMAT 5

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


173  LABEL     ERROR6 $
174  PRTPARM   //C,N,-6/C,N,BUCKLING $
175  LABEL     FINIS $
176  END       $
```

3.6.2 Description of DMAP Operations for Buckling Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations and tables to relate internal to external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot output is requested.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plots are requested.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Static Loads Table and Grid Point Temperature Table.

26. TA1 generates element tables for use in matrix assembly and stress recovery.

28. Go to DMAP No. 163 and print error message if no structural elements.

32. EMG generates structural element matrix stiffness and mass tables and dictionaries for later assembly.

35. Go to DMAP No. 38 if no stiffness matrix is to be assembled.

36. EMA assembles stiffness matrix $[K^{X}_{gg}]$ and Grid Point Singularity Table.

39. Go to DMAP No. 42 if no mass matrix is to be assembled.

40. EMA assembles mass matrix $[M_{gg}]$.

43. Go to DMAP No. 47 if no gravity loads and no weight and balance request.

44. Go to DMAP No. 171 and print error message if no mass matrix exists.

45. GPWG generates weight and balance information.

46. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

48. Equivalence $[K^{X}_{gg}]$ to $[K_{gg}]$ if no general elements.

50. Go to DMAP No. 53 if no general elements.

51. SMA3 adds general elements to $[K^{X}_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

55. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

57. Go to DMAP No. 173 and print error message if no independent degrees of freedom are defined.

61. Go to DMAP No. 63 if no free-body supports.

62. Go to DMAP No. 165 and print error message if free-body supports are present.

64. Go to DMAP No. 69 if general elements present.

65. GPSP determines if possible grid point singularities remain.

67. Go to DMAP No. 69 if no Grid Point Singularity Table.

68. ØFP formats table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

70. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

72. Go to DMAP No. 77 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

73. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

75. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

78. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

80. Go to DMAP No. 83 if no single-point constraints.

81. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right].$$

84. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

86. Go to DMAP No. 89 if no omitted coordinates.

87. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right],$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

90. RBMG2 decomposes constrained stiffness matrix $[K_{aa}] = [L_{\ell\ell}][U_{\ell\ell}]$.

92. SSG1 generates static load vectors $\{P_g\}$.

94. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

96. Go to DMAP No. 99 if no constraints applied.

97. SSG2 applies constraints to static load vectors

$$\{P_g\} = \begin{Bmatrix} \bar{P}_n \\ \hline P_m \end{Bmatrix}, \quad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\},$$

$$\{P_n\} = \begin{Bmatrix} \bar{P}_f \\ \hline P_s \end{Bmatrix}, \quad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\},$$

$$\{P_f\} = \begin{Bmatrix} P_a \\ \hline P_o \end{Bmatrix} \text{ and } \{P_\ell\} = \{P_a\} + [G_o^T]\{P_o\} \quad .$$

100. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell\} ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\},$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{\ell\ell}]\{u_\ell\}$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\},$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o\}} .$$

103. Go to DMAP No. 106 if residual vectors are not to be printed.

104. MATGPR prints residual vector for independent coordinates (RULV).

105. MATGPR prints residual vector for omitted coordinates (RUØV).

107. SDR1 recovers dependent displacements

$$\{u_o\} = [G_o]\{u_\ell\} + \{u_o^o\} ,$$

$$\left\{\begin{matrix} u_a \\ \hline u_o \end{matrix}\right\} = \{u_f\} , \qquad \left\{\begin{matrix} u_f \\ \hline Y_s \end{matrix}\right\} = \{u_n\},$$

$$\{u_m\} = [G_m]\{u_n\} , \qquad \left\{\begin{matrix} u_n \\ \hline u_m \end{matrix}\right\} = \{u_g\},$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\} .$$

109. SDR2 calculates element forces (ØEF1) and stresses (ØES1) and prepares load vectors (ØPG1), displacement vectors (ØUGV1), and single-point forces of constraint (ØQG1) for output and translation components of the displacement vector (PUGV1) for the static solution.

111. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

113. Go to DMAP No. 117 if no static solution deformed structure plots are requested.

114. PLØT generates all requested static solution deformed structure and contour plots.

116. PRTMSG prints plotter data, engineering data, and contour data for each static solution deformed plot generated.

118. TA1 generates element tables for use in differential stiffness matrix assembly.

119. DSMG1 generates differential stiffness matrix $[K_{gg}^d]$.

121. Equivalence $[K_{gg}^d]$ to $[K_{nn}^d]$ if no multipoint constraints.

123. Go to DMAP No. 126 if no multipoint constraints.

124. MCE2 partitions differential stiffness matrix

$$[K_{gg}^d] = \left[\begin{matrix} K_{nn}^d & | & K_{nm}^d \\ \hline K_{mn}^d & | & K_{mm}^d \end{matrix}\right]$$

and performs matrix reduction $[K_{nn}^d] = [\bar{K}_{nn}^d] + [G_m^T][K_{mn}^d] + [K_{mn}^d][G_m] + [G_m^T][K_{mm}^d][G_m]$.

127. Equivalence $[K_{nn}^d]$ to $[K_{ff}^d]$ if no single-point constraints.

129. Go to DMAP No. 132 if no single-point constraints.

130. SCE1 partitions out single-point constraints

$$[K_{nn}^d] = \left[\begin{matrix} K_{ff}^d & | & K_{fs}^d \\ \hline K_{sf}^d & | & K_{ss}^d \end{matrix}\right]$$

133. Equivalence $[K^d_{ff}]$ to $[K^d_{aa}]$ if no omitted coordinates.

135. Go to DMAP No. 138 if no omitted coordinates.

136. SMP2 partitions constrained differential stiffness matrix

$$[K^d_{ff}] = \left[\begin{array}{c|c} K^{-d}_{aa} & K^d_{ao} \\ \hline K^d_{oa} & K^d_{oo} \end{array}\right]$$

and performs matrix reduction $[K^d_{aa}] = [K^{-d}_{aa}] + [K^d_{oa}]^T[G_o] + [G_o]^T[K^d_{oa}] + [G_o]^T[K^d_{oo}][G_o]$.

139. ADD $-[K^d_{aa}]$ and nothing to create $[K^{dm}_{aa}]$.

141. DPD extracts Eigenvalue Extraction Data from Dynamics data block.

143. Go to DMAP No. 167 and print error message if no Eigenvalue Extraction Data.

146. READ extracts real eigenvalues from the equation

$$[K_{\ell\ell} + \lambda K^{dm}_{\ell\ell}]\{u_\ell\} = 0$$

and normalizes eigenvectors according to one of the following user requests:
1) Unit value of selected coordinate
2) Unit value of largest component

149. ØFP formats eigenvalues (LAMA) and summary of eigenvalue extraction information (ØEIGS) prepared by READ and places them on the system output file for printing.

151. Go to DMAP No. 169 and print error message if no eigenvalues found.

152. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o]\{\phi_a\}, \qquad \left\{\begin{array}{c}\phi_a \\ \hline \phi_o\end{array}\right\} = \{\phi_f\},$$

$$\left\{\begin{array}{c}\phi_f \\ \hline \phi_s\end{array}\right\} = \{\phi_n\}, \qquad \{\phi_m\} = [G_m]\{\phi_n\},$$

$$\left\{\begin{array}{c}\phi_n \\ \hline \phi_m\end{array}\right\} = \{\phi_g\}$$

and recovers single point forces of constraint $\{q_s\} = [K^T_{fs}]\{\phi_f\}$.

154. SDR2 calculates element forces (ØBEF1) and stresses (ØBES1) and prepares eigenvectors (ØPHIG) and single-point forces of constraint (ØBQG1) for output and translation components of the eigenvectors (PPHIG) for the buckling solution.

155. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

157. Go to DMAP No. 161 if no deformed buckling solution structure plots are requested.

158. PLØT generates all requested deformed buckling solution structure and contour plots.

160. PRTMSG prints plotter data, engineering data, and contour data for each deformed buckling solution plot generated.

162. Go to DMAP No. 175 and make normal exit.

164. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 1 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

166. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 2 - FREE BØDY-SUPPØRTS NØT ALLØWED.

168. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 3 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

170. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 4 - NØ EIGENVALUES FØUND.

172. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 5 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

174. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 6 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

3.7 PIECEWISE LINEAR ANALYSIS

3.7.1 DMAP Sequence for Piecewise Linear Analysis

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 6

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN    NO.6 PEICEWISE LINEAR STATIC ANALYSIS - SERIES P $

    2  FILE     OG1=APPEND/UGV1=APPEND/KGGSUM=SAVE/PGV1=APPEND $

    3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT $

    4  SAVE     LUSET $

    5  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

    6  GP2      GEOM2,EQEXIN/ECT $

    7  CHKPNT   ECT $

    8  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

    9  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

   10  COND     P1,NOPCDB $

   11  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/  V,N,
                JUMPPLOT=-1 $

   12  SAVE     NSIL,JUMPPLOT $

   13  PRTMSG   PLTSETX// $

   14  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

   15  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

   16  COND     P1,JUMPPLOT $

   17  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N
                NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

   18  SAVE     JUMPPLOT,PLTFLG,PFILE $


   19  PRTMSG   PLOTX1// $

   20  LABEL    P1 $

   21  CHKPNT   PLTPAR,GPSETS,ELSETS $

   22  GP3      GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $

   23  SAVE     NOGRAV $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 6

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


24  PARAM     //C,N,AND/V,N,SKPMGG/V,N,NOGRAV/V,Y,GRDPNT $

25  CHKPNT    SLT,GPTT $

26  TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,ECPT,GPCT/V,N,LUSET/
              V,N,NOSIMP/C,N,2/V,N,NOGENL/V,N,GENEL $

27  SAVE      NOSIMP,NOGENL,GENEL $

28  PARAM     //C,N,AND/V,N,NOELMT/V,N,NOGENL/V,N,NOSIMP $

29  COND      ERROR4,NOELMT $

30  PURGE     GPST/NOSIMP/OGPST/GENEL $

31  CHKPNT    EST,ECPT,GPECT,GEI,OGPST,GPCT $

32  COND      LBL1,NOSIMP $

33  PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

34  PARAM     //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

35  EMG       EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
              N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/  C,Y,
              CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/C,Y,CPTUBE/ C,Y,
              CPQDPLT/C,Y,CTRPLT/C,Y,CPTRBSC $

36  SAVE      NOKGGX,NOMGG $

37  CHKPNT    KELM,KDICT,MELM,MDICT $

38  COND      JMPKGG,NOKGGX $

39  EMA       GPECT,KDICT,KELM/KGGX,GPST $

40  CHKPNT    KGGX,GPST $

41  LABEL     JMPKGG $


42  COND      JMPMGG,NOMGG $

43  EMA       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

44  CHKPNT    MGG $

45  LABEL     JMPMGG $

46  COND      LBL1,GRDPNT $

47  COND      ERROR3,NOMGG $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 6

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


48  GPWG     BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/V,Y,WTMASS $
49  OFP      OGPWG,,,,,// $
50  LABEL    LBL1 $
51  PLA1     CSTM,MPT,ECPT,GPCT,DIT,CASECC,EST/KGGXL,ECPTNL,ESTL,ESTNL/V,N,
             KGGLPG/V,N,NPLALIM/V,N,ECPTNLPG/V,N,PLSETNO/V,N,NONLSTR/V,N,
             PLFACT $
52  SAVE     KGGLPG,NPLALIM,ECPTNLPG,PLSETNO,NONLSTR,PLFACT $
53  COND     ERROR1,ECPTNLPG $
54  PURGE    ONLES,ESTNL1/NONLSTR $
55  CHKPNT   KGGXL,ECPTNL,ESTL,ESTNL,ESTNL1 $
56  PARAM    //C,N,ADD/V,N,ALWAYS/C,N,-1/C,N,0 $
57  PARAM    //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $
58  EQUIV    KGGX,KGG/NOGENL/KGGXL,KGGL/NOGENL $
59  CHKPNT   KGG,KGGL $
60  COND     LBL11,NOGENL $
61  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
62  CHKPNT   KGG $
63  SMA3     GEI,KGGXL/KGGL/V,N,LUSET/V,N,NOGENL/V,N,KGGLPG $
64  CHKPNT   KGGL $
65  LABEL    LBL11 $
66  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $


67  GP4      CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N,LUSET/
             V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
             N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
 8  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $
 9  PARAM    //C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT $
 0  PURGE    KRR,KLR,OR,DM/REACT/GM/MPCF1/GO,KOO,LOO,PO,UOOV,PUOV/OMIT/PS,
             KFS,KSS/SINGLE/OG/NOSR $
    CHKPNT   KRR,KLR,OR,DM,GM,GO,KOO,LOO,PO,UOOV,QG,PS,KFS,KSS,USET,RG,YS,
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 6

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

                PUOV $
72  (SSG1)      SLT,BGPDT,CSTM,SIL,EST,MPT,,,MGG,CASECC,DIT/PG1/V,N,    LUSET/C,
                N,1 $
73  CHKPNT      PG1 $
74  EQUIV       PG1,PL/NOSET $
75  CHKPNT      PL $
76  COND        LBL4,GENEL $
77  (GPSP)      GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
78  SAVE        NOGPST $
79  COND        LBL4,NOGPST $
80  OFP         OGPST,,,,,// $
81  LABEL       LBL4 $
82  PARAM       //C,N,ADD/V,N,PLACOUNT/C,N,1/C,N,0 $
83  EQUIV       KGG,KNN/MPCF1 $
84  CHKPNT      KNN $
85  COND        LBL2,MPCF2 $
86  (MCE1)      USET,RG/GM $
87  CHKPNT      GM $
88  PARAM       //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
89  JUMP        LOOPBGN $                          (Top of DMAP Loop)
90  LABEL       LOOPBGN $

91  EQUIV       KGG,KNN/MPCF2 $
92  CHKPNT      KNN $
93  COND        LBL2,MPCF2 $
94  (MCE2)      USET,GM,KGG,,,/KNN,,, $
95  CHKPNT      KNN $
96  LABEL       LBL2 $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 6

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


 97  EQUIV     KNN,KFF/SINGLE $
 98  CHKPNT    KFF $
 99  COND      LBL3,SINGLE $
100  SCE1      USET,KNN,,,,/KFF,KFS,KSS,,,, $
101  CHKPNT    KFS,KSS,KFF $
102  LABEL     LBL3 $
103  EQUIV     KFF,KAA/OMIT $
104  CHKPNT    KAA $
105  COND      LBL5,OMIT $
106  SMP1      USET,KFF,,,,/GO,KAA,KOO,LOO,,,,, $
107  CHKPNT    GO,KAA,KOO,LOO $
108  LABEL     LBL5 $
109  EQUIV     KAA,KLL/REACT $
110  CHKPNT    KLL $
111  COND      LBL6,REACT $
112  RBMG1     USET,KAA,/KLL,KLR,KRR,,, $
113  CHKPNT    KLL,KLR,KRR $
114  LABEL     LBL6 $
115  DECOMP    KLL/LLL,/C,N,1/C,N,0/V,N,MINDIAGK/V,N,DETKLLXX/V,N,IDETKLLXX/ V,
               N,SINGKLLX $
116  SAVE      SINGKLLX $


117  COND      PLALBL4,SINGKLLX $
118  CHKPNT    LLL $
119  COND      LBL7,REACT $
120  RBMG3     LLL,KLR,KRR/DM $
121  CHKPNT    DM $
122  LABEL     LBL7 $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 6

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


123  ADD       PG1,/PG/V,N,PLFACT $
124  CHKPNT    PG $
125  COND      LBL10,NOSET $
126  SSG2      USET,GM,YS,KFS,GO,DM,PG/QR,PO,PS,PL $
127  CHKPNT    QR,PO,PS,PL $
128  LABEL     LBL10 $
129  SSG3      LLL,KLL,PL,LOO,KOO,PO/ULV,UOOV,RULV,RUOV/V,N,OMIT/V,Y,IRES=-1/
               V,N,PLACOUNT/V,N,EPSI $
130  SAVE      EPSI $
131  CHKPNT    ULV,UOOV,RULV,RUOV $
132  COND      LBL9,IRES $
133  MATGPR    GPL,USET,SIL,RULV//C,N,L $
134  MATGPR    GPL,USET,SIL,RUOV//C,N,O $
135  LABEL     LBL9 $
136  SDR1      USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,QR/DELTAUGV,DELTAPG,
               DELTAQG/C,N,1/C,N,STATICS $
137  CHKPNT    DELTAUGV,DELTAPG,DELTAQG $
138  PLA2      DELTAUGV,DELTAPG,DELTAQG/UGV1,PGV1,QG1/V,N,PLACOUNT $
139  SAVE      PLACOUNT $
140  CHKPNT    UGV1,QG1,PGV1 $
141  EQUIV     ESTNL,ESTNL1/NEVER/ECPTNL,ECPTNL1/NEVER $


142  COND      PLALBL2A,NONLSTP $
143  PLA3      CSTM,MPT,DIT,DELTAUGV,ESTNL,CASECC/ONLES,ESTNL1/V,N,PLACOUNT/
               V,N,PLSETNO $
144  CHKPNT    ESTNL1 $
145  OFP       ONLES,,,,,//V,N,CARDNO $
146  SAVE      CARDNO $
147  LABEL     PLALBL2A $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 6

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


148  PARAM     //C,N,SUB/V,N,DIFF/V,N,NPLALIM/V,N,PLACOUNT $

149  COND      PLALBL5,DIFF $

150  PLA4      CSTM,MPT,ECPTNL,GPCT,DIT,DELTAUGV/KGGNL,ECPTNL1/V,N,PLACOUNT/V,
               N,PLSETNO/V,N,PLFACT $

151  SAVE      PLACOUNT,PLSETNO,PLFACT $

152  CHKPNT    KGGNL,ECPTNL1 $

153  EQUIV     KGGNL,KGGSUM/KGGLPG $

154  CHKPNT    KGGSUM $

155  COND      PLALBL3,KGGLPG $

156  ADD       KGGNL,KGGL/KGGSUM $

157  CHKPNT    KGGSUM $

158  LABEL     PLALBL3 $

159  EQUIV     KGGSUM,KGG/ALWAYS $

160  CHKPNT    KGG $

161  EQUIV     ESTNL1,ESTNL/ALWAYS/ECPTNL1,ECPTNL/ALWAYS $

162  CHKPNT    ESTNL,ECPTNL $

163  REPT      LOOPBGN,360 $

164  JUMP      ERROR2 $

165  LABEL     PLALBL4 $

166  PRTPARM   //C,N,-5/C,N,PLA $

167  LABEL     PLALBL5 $


168  SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,OGL,UGV1,ESTL,,
               PGV1/OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,PLA $

169  OFP       OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $

170  SAVE      CARDNO $

171  COND      P2,JUMPPLOT $

172  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,,ECPT,OES1/
               PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
```

Bottom of DMAP Loop

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 6

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


173  SAVE     PFILE $
174  PRTMSG   PLOTX2// $
175  LABEL    P2 $
176  JUMP     FINIS $
177  LABEL    ERROR1 $
178  PRTPARM  //C,N,-1/C,N,PLA $
179  LABEL    ERROR2 $
180  PRTPARM  //C,N,-2/C,N,PLA $
181  LABEL    ERROR3 $
182  PRTPARM  //C,N,-3/C,N,PLA $
183  LABEL    ERROR4 $
184  PRTPARM  //C,N,-4/C,N,PLA $
185  LABEL    FINIS $
```

3.7.2 Description of DMAP Operations for Piecewise Linear Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot output is requested.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plots are requested.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Static Loads Table and Grid Point Temperature Table.

26. TA1 generates element tables for use in matrix assembly and stress recovery.

29. Go to DMAP No. 183 and print error message if no elements have been defined.

32. Go to DMAP No. 50 if there are no structural elements.

35. EMG generates strcutural element stiffness and mass matrix tables and dictionaries for later assembly.

38. Go to DMAP No. 41 if no stiffness matrix is to be assembled.

39. EMA assembles stiffness matrix $[K^{x}_{gg}]$ and Grid Point Singularity Table.

42. Go to DMAP No. 45 if no mass matrix is to be assembled.

43. EMA assembles mass matrix $[M_{gg}]$.

46. Go to DMAP No. 50 if no weight and balance is requested.

47. Go to DMAP No. 181 and print error message if no mass matrix exists.

48. GPWG generates weight and balance information.

49. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

51. PLA1 extracts the linear terms from $[K^{x}_{gg}]$ to give $[K^{x\ell}_{gg}]$, extracts the nonlinear entries from the Element Connection and Properties Table to give ECPTNL, and separates the linear and nonlinear entries in the Element Summary Table to give ESTL and ESTNL.

53. Go to DMAP No. 177 and print error message if no elements have a stress dependent modulus of elasticity.

58. Equivalence $[K^{x}_{gg}]$ to $[K_{gg}]$ and $[K^{x\ell}_{gg}]$ to $[K^{\ell}_{gg}]$ if no general elements.

60. Go to DMAP No. 65 if no general elements.

61. SMA3 adds general elements to $[K^{x}_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

63. MSA3 adds general elements to $[K^{x\ell}_{gg}]$ to obtain stiffness matrix of linear elements $[K^{\ell}_{gg}]$.

67. GP4 generates flags defining members of various displacment sets (USET), forms multi-point constraint equations $[R_g]\{u_g\} = 0$.

72. SSG1 generates total static load vector $\{P_g^1\}$

74. Equivalence $\{P_g^1\}$ to $\{P_\ell\}$ if no constraints applied.

76. Go to DMAP No. 79 if general elements present.

77. GPSP determines if possible grid point singularities remain.

79. Go to DMAP No. 81 if no Grid Point Singularity Table.

80. ØFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing

83. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

85. Go to DMAP No. 96 if no multipoint constraints.

86. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

89. Go to next DMAP instruction if cold start or modified restart. LØØPBGN will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

90. Beginning of loop for additional load increments.

91. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

93. Go to DMAP No. 91 if no multipoint constraints.

94. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

97. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

99. Go to DMAP No. 102 if no single-point constraints.

100. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] .$$

103. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

105. Go to DMAP No. 108 if no omitted coordinates.

106. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right],$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$
and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

109. Equivalence $[K_{aa}]$ to $[K_{\ell\ell}]$ if no free-body supports.

111. Go to DMAP No. 107 if no free-body supports.

112. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right]$$

115. DECØMP decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

117. Go to DMAP No. 165 and print error message if stiffness matrix $[K_{\ell\ell}]$ is singular (i.e., local plasticity).

119. Go to DMAP No. 122 if no free-body supports.

120. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||}$$

123. ADD multiplies total load vector $\{P_g^1\}$ by factor, PLFACT, and adds it to nothing to obtain applied load vector $\{P_g\}$ for current loop.

125. Go to DMAP No. 128 if no constraints applied.

126. SSG2 applies constraints to static load vector for current loop.

$$\{P_g\} = \left\{\begin{array}{c} \bar{P}_n \\ \hline P_m \end{array}\right\}, \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\},$$

$$\{P_n\} = \left\{\begin{array}{c} \bar{P}_f \\ \hline P_s \end{array}\right\}, \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\},$$

$$\{P_f\} = \left\{\begin{array}{c} \bar{P}_a \\ \hline P_o \end{array}\right\}, \qquad \{P_a\} = \{\bar{P}_a\} + [G_o^T]\{P_o\},$$

$$\{P_a\} = \left\{\begin{array}{c} P_\ell \\ \hline P_r \end{array}\right\}$$

and calculates incremental determinate forces of reaction for current loop

$$\{q_r\} = -\{P_r\} - [D^T]\{P_\ell\}.$$

129. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell\} ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\},$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{\ell\ell}]\{u_\ell\} .$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\},$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o^o\}} .$$

132. Go to DMAP No. 135 if residual vectors are not to be printed.

133. MATGPR prints residual vector for independent coordinates (RULV).

134. MATGPR prints residual vector for omitted coordinates (RUØV).

136. SDR1 recovers dependent incremental displacements for current loop

$$\begin{Bmatrix} u_\ell \\ \hline u_r \end{Bmatrix} = \{u_a\}, \qquad \{u_o\} = [G_o]\{u_a\} + \{u_o^o\},$$

$$\begin{Bmatrix} u_a \\ \hline u_o \end{Bmatrix} = \{u_f\} , \qquad \begin{Bmatrix} u_f \\ \hline Y_s \end{Bmatrix} = \{u_n\} ,$$

$$\{u_m\} = [G_m]\{u_n\}, \qquad \begin{Bmatrix} u_n \\ \hline u_m \end{Bmatrix} = \{u_g\} ,$$

and recovers incremental single-point forces of constraint for current loop

$$\{\delta q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} .$$

138. PLA2 adds the incremental displacement vector (DELTAUGV) and the incremental single-point forces of constraint vector (DELTAQG) for the current loop to the accumulated sum of these vectors (DELTAPG).

$$\{u_{g_{i+1}}\} = \{\delta u_{g_i}\} + \{u_{g_i}\} \quad \text{and}$$

$$\{q_{g_{i+1}}\} = \{\delta q_{g_i}\} + \{q_{g_i}\}$$

141. Allocate separate files for ESTNL and ESTNL1 and for ECPTNL and ECPTNL1.

142. Go to DMAP No. 147 if no stress output requested for nonlinear elements.

143. PLA3 calculates incremental stresses in nonlinear elements (ØNLES) for which an output request has been made and updates the accumulated stresses (ESTNL1) in these elements.

145. ØFP formats the accumulated stresses in nonlinear elements prepared by PLA3 and places them on the system output file for printing.

149. Go to DMAP No. 167 if all loading increments have been completed.

150. PLA4 generates stiffness matrix for nonlinear elements $[K_{gg}^{n\ell}]$ and updates stress information.

153. Equivalence $[K_{gg}^{n\ell}]$ to $[K_{gg}]$ if all elements are nonlinear.

155. Go to DMAP No. 158 if all elements are nonlinear.

156. Add stiffness matrix for nonlinear elements (KGGNL) to stiffness matrix for linear elements (KGGL)

$$[K_{gg}^{n\ell}] + [K_{gg}^{\ell}] = [K_{gg}^{sum}]$$

159. Equivalence $[K_{gg}^{sum}]$ to $[K_{gg}]$ for next pass through loop.

161. Equivalence existing element tables to updated tables for next pass thorugh loop.

163. Go to DMAP No. 89 if additional load increments need to be processed.

164. Go to DMAP No. 179 and print error message if more than 360 loops.

166. PIECEWISE LINEAR ANALYSIS ERRØR MESSAGE NØ. 5 - STIFFNESS MATRIX SINGULAR DUE TØ MATERIAL PLASTICITY.

168. SDR2 calculates element forces (ØEF1) and stresses for linear elements (ØES1) and prepares load vectors (ØPG1), displacement vectors (ØUGV1), and single-point forces of constraint (ØQG1) for output and translation components of the displacement vector (PUGV1).

169. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

171. Go to DMAP No. 175 if no deformed structure plots are requested.

172. PLØT generates all requested deformed structure and contour plots.

174. PRTMSG prints plotter data, engineering data, and contour data for each deformed plot generated.

176. Go to DMAP No. 185 and make normal exit.

178. PIECEWISE LINEAR ANALYSIS ERRØR MESSAGE NØ. 1 - NØ NØNLINEAR ELEMENTS HAVE BEEN DEFINED.

180. PIECEWISE LINEAR ANALYSIS ERRØR MESSAGE NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 360 LØØPS.

182. PIECEWISE LINEAR ANALYSIS ERRØR MESSAGE NØ. 3 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

184. PIECEWISE LINEAR ANALYSIS ERRØR MESSAGE NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

3.7.3 Case Control Deck and Parameters for Piecewise Linear Analysis

The following items relate to subcase definition and data selection for Piecewise Linear Analysis:

1. The Case Control Deck must contain one and only one subcase.
2. A static loading condition must be defined with a LØAD selection.
3. An SPC set must be selected unless all constraints are specified on GRID cards.
4. PLCØEFFICIENT must appear either to select a PLFACT set from the Bulk Data Deck or to explicitly select the default value of unity.

The following output may be requested for Piecewise Linear Analysis:

1. Accumulated sums of displacements and nonzero components of the static loads and single-point forces of constraint at selected grid points for each load increment.
2. Stresses in selected elements. If an element is composed of a nonlinear material the accumulated stress will be output for each load increment. Stresses in linear elements are only calculated for the total load.
3. Undeformed plot of the structural model and deformed plots for each load increment.
4. Contour plots of stress and displacement for each load increment.

The following parameters are used in Piecewise Linear Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.
2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in SMA2.
3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.
4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

3.8 DIRECT COMPLEX EIGENVALUE ANALYSIS

3.8.1 DMAP Sequence for Direct Complex Eigenvalue Analysis

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 7

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN    NO.7 DIRECT COMPLEX EIGENVALUE ANALYSIS - SERIES P $

    2  FILE     KGGX=TAPE/ KGG=TAPE/ GOD=SAVE/ GMD=SAVE $

    3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT $

    4  SAVE     LUSET,NOGPDT $

    5  PURGE    USET,GM,GO,KAA,BAA,MAA,K4AA,KFS,EST,ECT,PLTSETX,PLTPAR,GPSETS,
                ELSETS/NOGPDT $

    6  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL,USET,GM,GO,KAA,BAA,MAA,K4AA,EST,
                ECT,PLTSETX,PLTPAR,GPSETS,ELSETS $

    7  COND     LBL5,NOGPDT $

    8  GP2      GEOM2,EQEXIN/ECT $

    9  CHKPNT   ECT $

   10  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

   11  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

   12  COND     P1,NOPCDB $

   13  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
                JUMPPLOT=-1 $

   14  SAVE     NSIL,JUMPPLOT $

   15  PRTMSG   PLTSETX// $

   16  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

   17  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $


   18  COND     P1,JUMPPLOT $

   19  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

   20  SAVE     PFILE $

   21  PRTMSG   PLOTX1// $

   22  LABEL    P1 $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 7

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


23   CHKPNT   PLTPAR,GPSETS,ELSETS $
24   GP3      GEOM3,EQEXIN,GEOM2/,CPTT/V,N,NOGRAV $
25   CHKPNT   GPTT $
26   TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,,/V,N,LUSET/V,N,
              NOSIMP=-1/C,N,1/V,N,NOGENL=-1/V,N,GENEL $
27   SAVE     NOSIMP,NOGENL,GENEL $
28   PURGE    K4GG,GPST,OGPST,MGG,BGG,K4NN,K4FF,K4AA,MNN,MFF,MAA,BNN,BFF,BAA,
              KGGX/NOSIMP / OGPST/GENEL $
29   CHKPNT   EST,GPECT,GEI,K4GG,GPST,MGG,BGG,KGGX,OGPST,  K4NN,K4FF,K4AA,
              MNN,MFF,MAA,BNN,BFF,BAA $
30   COND     LBL1,NOSIMP $
31   PARAM    //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $
32   PARAM    //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $
33   PARAM    //C,N,ADD/V,N,NOBGG=-1/C,N,1/C,N,0 $
34   PARAM    //C,N,ADD/V,N,NOK4GG/C,N,1/C,N,0 $
35   EMG      EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,BELM,BDICT/V,N,
              NOKGGX/V,N,NOMGG/V,N,NOBGG/V,N,NOK4GG/C,N,/C,Y,COUPMASS/C,Y,
              CPBAR/C,Y,CPROD/C,Y,CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,
              CPTRIA2/C,Y,CPTUBE/C,Y,CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $
36   SAVE     NOKGGX,NOMGG,NOBGG,NOK4GG $
37   CHKPNT   KELM,KDICT,MELM,MDICT,BELM,BDICT $
38   COND     LBLKGGX,NOKGGX $
39   EMA      GPECT,KDICT,KELM/KGGX,GPST $


40   CHKPNT   KGGX,GPST $
41   LABEL    LBLKGGX $
42   COND     LBLMGG,NOMGG $
43   EMA      GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $
44   CHKPNT   MGG $
45   LABEL    LBLMGG $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 7

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


46  COND      LBLBGG,NOBGG $
47  (EMA)     GPECT,BDICT,BELM/BGG, $
48  CHKPNT    BGG $
49  LABEL     LBLBGG $
50  COND      LBLK4GG,NOK4GG $
51  (EMA)     GPECT,KDICT,KELM/K4GG,/V,N,NOK4GG $
52  CHKPNT    K4GG $
53  LABEL     LBLK4GG $
54  PURGE     MNN,MFF,MAA/NOMGG $
55  PURGE     BNN,BFF,BAA/NOBGG $
56  CHKPNT    MGG,MNN,MFF,MAA,BGG,BNN,BFF,BAA $
57  COND      LBL1,GRDPNT $
58  COND      ERROR3,NOMGG $
59  (GPWG)    BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS $
60  OFP       OGPWG,,,,,// $
61  LABEL     LBL1 $
62  EQUIV     KGGX,KGG/NOGENL $
63  CHKPNT    KGG $
64  COND      LBL11,NOGENL $
65  (SMA3)    GET,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

66  CHKPNT    KGG $
67  LABEL     LBL11 $
68  PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
69  (GP4)     CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,LUSET/
              V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
              N,REPEAT/V,N,NOSET=-1/V,N,NOL/V,N,NOA=-1/   C,Y,SUBID $
70  SAVE      MPCF1,MPCF2,SINGLE,OMIT,NSKIP,NOSET,REACT,REPEAT,NOL,NOA $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 7

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


71  PURGE    GM,GMD/MPCF1/GO,GOD/OMIT/KFS,QPC/SINGLE $
72  CHKPNT   GM,GMD,RG,GO,GOD,KFS,QPC $
73  COND     LBL4,GENFL $
74  COND     LBL4,NOSIMP $
75  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
76  SAVE     NOGPST $
77  COND     LBL4,NOGPST $
78  OFP      OGPST,,,,,// $
79  LABEL    LBL4 $
80  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1/ BGG,BNN/MPCF1/K4GG,K4NN/MPCF1 $
81  CHKPNT   KNN,MNN,BNN,K4NN $
82  COND     LBL2,MPCF2 $
83  MCE1     USET,RG/GM $
84  CHKPNT   GM $
85  MCE2     USET,GM,KGG,MGG,BGG,K4GG/KNN,MNN,BNN,K4NN $
86  CHKPNT   KNN,MNN,BNN,K4NN $
87  LABEL    LBL2 $
88  EQUIV    KNN,KFF/SINGLE/MNN,MFF/SINGLE/BNN,BFF/SINGLE/K4NN,K4FF/SINGLE $
89  CHKPNT   KFF,MFF,BFF,K4FF $
90  COND     LBL3,SINGLE $

91  SCE1     USET,KNN,MNN,BNN,K4NN/KFF,KFS,,MFF,BFF,K4FF $
92  CHKPNT   KFS,KFF,MFF,BFF,K4FF $
93  LABEL    LBL3 $
94  EQUIV    KFF,KAA/OMIT/ MFF,MAA/OMIT/BFF,BAA/OMIT/K4FF,K4AA/OMIT $
95  CHKPNT   KAA,MAA,BAA,K4AA $
96  COND     LBL5,OMIT $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 7

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


 97 (SMP1)   USET,KFF,,,,/GO,KAA,KOO,LOO,,,,, $
 98  CHKPNT  GO,KAA $
 99  COND    LBLM,NOMGG $
100 (SMP2)   USET,GO,MFF/MAA $
101  CHKPNT  MAA $
102  LABEL   LBLM $
103  COND    LBLB,NOBGG $
104 (SMP2)   USET,GO,BFF/BAA $
105  CHKPNT  BAA $
106  LABEL   LBLB $
107  COND    LBL5,NOK4GG $
108 (SMP2)   USET,GO,K4FF/K4AA $
109  CHKPNT  K4AA $
110  LABEL   LBL5 $
111 (DPD)    DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,,,,,,EED,EQDYN/V,
             N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/
             V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,123/V,N,NOUE $
112  SAVE    LUSETD,NOUE $
113  EQUIV   GO,GOD/NOUE/GM,GMD/NOUE $
114  CHKPNT  USETD,EED,EQDYN,TFPOOL,GOD,GMD,SILD,GPLD $
115  PARAM   //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $

116  PARAM   //C,N,MPY/V,N,REPEATE/C,N,1/C,N,-1 $
117 (BMG)    MATPOOL,BGPDT,EQEXIN,CSTM/BDPOOL/V,N,NOKBFL/V,N,NOABFL/ V,N,
             MFACT $
118  SAVE    MFACT,NOKBFL,NOABFL $
119  PARAM   //C,N,AND/V,N,NOFL/V,N,NOABFL/V,N,NOKBFL $
120  PURGE   KBFL/NOKBFL/ ABFL/NOABFL $
121  COND    LBLFL3,NOFL $
```

```
RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 7

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


122  MTRXIN,   ,BDPOOL,EQDYN,,/ABFL,KBFL,/V,N,LUSETD/V,N,NOABFL/V,N,NOKBFL/C,
               N,0 $
123  SAVE      NOABFL,NOKBFL $
124  LABEL     LBLFL3 $
125  CHKPNT    ABFL,KBFL $
126  PARAM     //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
127  JUMP      LBL13 $
                                                    Top of DMAP Loop
128  LABEL     LBL13 $
129  PURGE     PHTD,CLAMA,OPHID,OQPC1,OCPHIP,OESC1,OEFC1,CPHIP,OPC,  K2PP,
               M2PP,B2PP,K2DD,M2DD,B2DD/NEVER $
130  CASE      CASECC,/CASEXX/C,N,CFIGN/V,N,REPEATE/V,N,NOLOOP $
131  SAVE      REPEATE,NOLOOP $
132  CHKPNT    CASEXX $
133  MTRXIN    CASEXX,MATPOOL,EQDYN,,TEPOOL/K2DPP,M2DPP,B2PP/V,N,LUSETD/V,N,
               NOK2DPP/V,N,NOM2DPP/V,N,NOB2PP $
134  SAVE      NOK2DPP,NOM2DPP,NOB2PP $
135  PARAM     //C,N,AND/V,N,NOM2PP/V,N,NOABFL/V,N,NOM2DPP $
136  PARAM     //C,N,AND/V,N,NOK2PP/V,N,NOEL /V,N,NOK2DPP $
137  EQUIV     M2DPP,M2PP/NOABFL $
138  ADD5      ABFL,KBFL,K2DPP,,/K2PP/C,N,(-1.0,0.0) $
139  COND      LBLFL2,NOABFL $
140  TRNSP     ABFL/ABFLT $


141  ADD       ABFLT,M2DPP/M2PP/V,N,MFACT $
142  LABEL     LBLFL2 $
143  PARAM     //C,N,AND/V,N,BDEBA/V,N,NOUE/V,N,NOB2PP $
144  PARAM     //C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP $
145  PARAM     //C,N,AND/V,N,KDEK2/V,N,NOGENL/V,N,NOSIMP $
146  PURGE     K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 7

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


147   EQUIV     M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDEMA/BAA,
                BDD/BDEBA $

148   CHKPNT    K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,BDD,MDD $

149   COND      LBL18,NOGPDT $

150   GKAD      USETD,GM,GO,KAA,BAA,MAA,K4AA,K2PP,M2PP,B2PP/KDD,BDD,MDD,GMD,
                GOD,K2DD,M2DD,B2DD/C,N,CMPLEV/C,N,DISP/C,N,DIRECT/C,Y,G=0.0/C,
                N,0.0/C,N,0.0/V,N,NOK2PP/V,N,NOM2PP/V,N,NOB2PP/   V,N,MPCF1/V,
                N,SINGLE/V,N,OMIT/V,N,NOUE/V,N,NOK4GG/V,N,NOBGG/V,N,KDEK2/C,N,
                -1 $

151   LABEL     LBL18 $

152   EQUIV     B2DD,BDD/NOBGG/M2DD,MDD/NOSIMP/ K2DD,KDD/KDEK2 $

153   CHKPNT    KDD,BDD,MDD,GOD,GMD $

154   COND      ERROR1,NOFED $

155   CEAD      KDD,BDD,MDD,FED,CASEXX/PHID,CLAMA,OCEIGS,/V,N,EIGVS $

156   SAVE      EIGVS $

157   CHKPNT    PHID,CLAMA,OCEIGS $

158   OFP       OCEIGS,CLAMA,,,,//V,N,CARDNO $

159   SAVE      CARDNO $

160   COND      LBL16,EIGVS $

161   VDR       CASEXX,EQDYN,USETD,PHID,CLAMA,,/OPHID,/C,N,CEIGN/C,N,DIRECT/C,
                N,0/V,N,NOD/V,N,NOP/C,N,0 $

162   SAVE      NOD,NOP $

163   COND      LBL15,NOD $


164   OFP       OPHID,,,,,//V,N,CARDNO $

165   SAVE      CARDNO $

166   LABEL     LBL15 $

167   COND      LBL16,NOP $

168   EQUIV     PHID,OPHIP/NOA $

169   COND      LBL17,NOA $
```

```
RIGID FORMAT DMAP LISTING
SERIES P.

DISPLACEMENT APPROACH, RIGID FORMAT 7

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


170 SDR1     USETD,, PHID,,,GOD,GMD,,KFS,,/CPHIP,,OPC/C,N,1/C,N,DYNAMICS
171 LABEL    LBL17 $
172 CHKPNT   CPHIP,OPC $
173 SDR2     CASEXX,CSTM,MPT,DIT,FODYN,SILD,,,,CLAMA,OPC,CPHIP,EST,,/,OQPC1,
             OCPHIP,OESC1,OEFC1,/C,N,CEIG $
174 OFP      OCPHIP,OQPC1,OEFC1,OESC1,,//V,N,CARDNO $
175 SAVE     CARDNO $
176 LABEL    LBL16 $
177 COND     FINIS,REPEATE $
178 REPT     LBL13,100 $                          Bottom of DMAP Loop
179 JUMP     ERROR2 $
180 JUMP     FINIS $
181 LABEL    ERROR2 $
182 PRTPARM  //C,N,-2/C,N,DIRCEAD $
183 LABEL    ERROR1 $
184 PRTPARM  //C,N,-1/C,N,DIRCEAD $
185 LABEL    ERROR3 $
186 PRTPARM  //C,N,-3/C,N,DIRCEAD $
187 LABEL    FINIS $
188 END      $
```

91. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] , \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right] ,$$

$$[B_{nn}] = \left[\begin{array}{c|c} B_{ff} & B_{fs} \\ \hline B_{sf} & B_{ss} \end{array}\right] \quad \text{and} \quad [K^4_{nn}] = \left[\begin{array}{c|c} K^4_{ff} & K^4_{fs} \\ \hline K^4_{sf} & K^4_{ss} \end{array}\right] .$$

94. Equivalence $[K_{ff}]$ to $[K_{aa}]$, $[M_{ff}]$ to $[M_{aa}]$, $[B_{ff}]$ to $[B_{aa}]$ and $[K^4_{ff}]$ to $[K^4_{aa}]$ if no omitted coordinates.

96. Go to DMAP No. 110 if no omitted coordinates.

97. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} K_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$ and performs matrix reduction

$$[K^1_{aa}] = [K_{aa}] + [K_{ao}][G_o]$$

99. Go to DMAP No.102 if no mass matrix.

100. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} M_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M^1_{aa}] = [M_{aa}] + [M_{ao}][G_o] + [M_{ao}G_o]^T + [G_o^T][M_{oo}][G_o]$$

103. Go to DMAP No.106 if no viscous damping matrix.

104. SMP2 partitions constrained viscous damping matrix

$$[B_{ff}] = \left[\begin{array}{c|c} B_{aa} & B_{ao} \\ \hline B_{oa} & B_{oo} \end{array}\right]$$

and performs matrix reduction

$$[B^1_{aa}] = [B_{aa}] + [B_{ao}][G_o] + [B_{ao}G_o]^T + [G_o^T][B_{oo}][G_o]$$

107. Go to DMAP No.110 if no structural damping matrix.

108. SMP2 partitions constrained structural damping matrix

$$[K^4_{ff}] = \left[\begin{array}{c|c} K^4_{aa} & K^4_{ao} \\ \hline K^4_{oa} & K^4_{oo} \end{array}\right]$$

and performs matrix reduction

$$[K^4_{aa}] = [K^4_{aa}] + [K^4_{ao}][G_o] + [K^4_{ao}G_o]^T + [G_o^T][K^4_{oo}][G_o]$$

111. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers (GPLD), including extra points introduced for dynamic analysis (SILD), and prepares Transfer Function Pool (TFPØØL), and Eigenvalue Extraction Data (EED).

113. Equivalence $[G_o]$ to $[G^d_o]$ and $[G_m]$ to $[G^d_m]$ if no extra points introduced for dynamic analysis.

117. BMG generates DMIG card images describing the interconnection of the fluid and the structure.

121. Go to DMAP No. 124 if no fluid structure interface is defined.

122. MTRXIN generates fluid boundary matrices $[A_{b,f\ell}]$ and $[K_{b,f\ell}]$ if a fluid structure interface is defined. The matrix $[K_{b,f\ell}]$ is generated only for a nonzero gravity in the fluid.

127. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

128. Beginning of loop for additional sets of direct input matrices.

130. CASE extracts user requests from CASECC for current loop.

133. MTRXIN selects the direct input matrices for the current loop, $[K^{2d}_{pp}]$, $[M^{2d}_{pp}]$ and $[B^2_{pp}]$.

137. Equivalence $[M^{2d}_{pp}]$ to $[M^2_{pp}]$ if no $[A_{b,f\ell}]$.

138. ADD5 adds $[K_{b,f\ell}]$ and $[K^{2d}_{pp}]$ and subtracts $[A_{b,f\ell}]$ from them to form $[K^2_{pp}]$.

139. Go to DMAP No. 142 if no $[A_{b,f\ell}]$.

140. Transpose $[A_{b,f\ell}]$ to obtain $[A_{b,f\ell}]^T$.

3.9 DIRECT FREQUENCY AND RANDOM RESPONSE

3.9.1 DMAP Sequence for Direct Frequency and Random Response

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT P

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   LOLIST  NODECK  NOREF   NOOSCAR

     1  BEGIN     NO.P DIRECT FREQUENCY RESPONSE ANALYSIS - SERIES P $

     2  FILE      KGGX=TAPE/ KGG=TAPE/ GOD=SAVE/ GMD=SAVE $

     3  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                  NOGPDT $

     4  SAVE      LUSET,NOGPDT $

     5  PURGE     USET,GM,GO,KAA,BAA,MAA,K4AA,KFS,PSF,QPC,EST,ECT,PLTSETX,PLTPAR,
                  GPSETS,ELSETS/NOGPDT $

     6  CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL,USET,GM,GO,KAA,BAA,MAA,K4AA,
                  KFS,PSF,QPC,EST,ECT,PLTSETX,PLTPAR,GPSETS,ELSETS $

     7  COND      LBL5,NOGPDT $

     8  GP2       GEOM2,EQEXIN/ECT $

     9  CHKPNT    ECT $

    10  PARAML    ECDB//C,N,PFLS/C,N,/C,N,/C,N,/V,N,NOPCDB $

    11  PURGE     PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

    12  COND      P1,NOPCDB $

    13  PLTSET    ECDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/  V,N,
                  JUMPPLOT=-1 $

    14  SAVE      NSIL,JUMPPLOT $

    15  PRTMSG    PLTSETX// $

    16  PARAM     //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

    17  PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $


    18  COND      P1,JUMPPLOT $

    19  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                  NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

    20  SAVE      PFILE $

    21  PRTMSG    PLOTX1// $

    22  LABEL     P1 $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 8

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


23  CHKPNT   PLTPAR,GPSETS,ELSETS $

24  GP3      GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $

25  CHKPNT   GPTT $

26  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,,,/V,N,LUSET/V,N,
             NOSIMP=-1/C,N,1/V,N,NOGENL=-1/V,N,GENEL $

27  SAVE     NOSIMP,NOGENL,GENEL $

28  PURGE    K4GG,GPST,OGPST,MGG,BGG,K4NN,K4FF,K4AA,MNN,MFF,MAA,BNN,BFF,BAA,
             KGGX/NOSIMP/OGPST/GENEL $

29  CHKPNT   EST,GPECT,GEI,K4GG,GPST,MGG,BGG,KGGX,OGPST,  K4NN,K4FF,K4AA,
             MNN,MFF,MAA,BNN,BFF,PAA $

30  COND     LBL1,NOSIMP $

31  PARAM    //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

32  PARAM    //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

33  PARAM    //C,N,ADD/V,N,NOBGG=-1/C,N,1/C,N,0 $

34  PARAM    //C,N,ADD/V,N,NOK4GG/C,N,1/C,N,0 $

35  EMG      EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,BELM,BDICT/  V,
             N,NOKGGX/V,N,NOMGG/V,N,NOBGG/V,N,NOK4GG/C,N,/C,Y,COUPMASS/C,Y,
             CPBAR/C,Y,CPROD/C,Y,CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,
             CPTRIA2/C,Y,CPTUBE/C,Y,CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

36  SAVE     NOKGGX,NOMGG,NOBGG,NOK4GG $

37  CHKPNT   KELM,KDICT,MELM,MDICT,BELM,BDICT $

38  COND     LBLKGGX,NOKGGX $

39  EMA      GPECT,KDICT,KELM/KGGX,GPST $


40  CHKPNT   KGGX,GPST $

41  LABEL    LBLKGGX $

42  COND     LBLMGG,NOMGG $

43  EMA      GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

44  CHKPNT   MGG $

45  LABEL    LBLMGG $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 8

   LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


46  COND      LBLBGG,NOBGG $
47  (EMA)     GPECT,BDICT,BELM/BGG, $
48  CHKPNT    BGG $
49  LABEL     LBLBGG $
50  COND      LBLK4GG,NOK4GG $
51  (EMA)     GPECT,KDICT,KELM/K4GG,/V,N,NOK4GG $
52  CHKPNT    K4GG $
53  LABEL     LBLK4GG $
54  PURGE     MNN,MFF,MAA/NOMGG $
55  PURGE     BNN,BFF,BAA/NOBGG $
56  CHKPNT    MGG,MNN,MFF,MAA,BGG,BNN,BFF,BAA $
57  COND      LBL1,GRDPNT $
58  COND      ERROR4,NOMGG $
59  (GPWG)    BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $
60  OFP       OGPWG,,,,,// $
61  LABEL     LBL1 $
62  EQUIV     KGGX,KGG/NOGENL $
63  CHKPNT    KGG $
64  COND      LBL11,NOGENL $
65  (SMA3)    GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

66  CHKPNT    KGG $
67  LABEL     LBL11 $
68  PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
69  (GP4)     CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,LUSET/
              V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
              N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
70  SAVE      MPCF1,SINGLE,OMIT,NOSET,REACT,MPCF2,NSKIP,REPEAT,NOL,NOA $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 8

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


71  PURGE     GM,GMD/MPCF1/GO,GOD/OMIT/KFS,PSF,QPC/SINGLE $
72  CHKPNT    GM,GMD,RG,GO,GOD,KFS,PSF,QPC,USET $
73  COND      LBL4,GENEL $
74  COND      LBL4,NOSIMP $
75  GPSP      GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
76  SAVE      NOGPST $
77  COND      LBL4,NOGPST $
78  OFP       OGPST,,,,,// $
79  LABEL     LBL4 $
80  EQUIV     KGG,KNN/MPCF1/MGG,MNN/MPCF1/ BGG,BNN/MPCF1/K4GG,K4NN/MPCF1 $
81  CHKPNT    KNN,MNN,BNN,K4NN $
82  COND      LBL2,MPCF1 $
83  MCE1      USET,RG/GM $
84  CHKPNT    GM $
85  MCE2      USET,GM,KGG,MGG,BGG,K4GG/KNN,MNN,BNN,K4NN $
86  CHKPNT    KNN,MNN,BNN,K4NN $
87  LABEL     LBL2 $
88  EQUIV     KNN,KFF/SINGLE/MNN,MFF/SINGLE/BNN,BFF/SINGLE/K4NN,K4FF/SINGLE $
89  CHKPNT    KFF,MFF,BFF,K4FF $
90  COND      LBL3,SINGLE $

91  SCE1      USET,KNN,MNN,BNN,K4NN/KFF,KFS,,MFF,BFF,K4FF $
92  CHKPNT    KFS,KFF,MFF,BFF,K4FF $
93  LABEL     LBL3 $
94  EQUIV     KFF,KAA/OMIT $
95  EQUIV     MFF,MAA/OMIT $
96  EQUIV     BFF,BAA/OMIT $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 8

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


 97  EQUIV     K4FF,K4AA/OMIT $
 98  CHKPNT    KAA,MAA,BAA,K4AA $
 99  COND      LBL5,OMIT $
100  SMP1      USET,KFF,,,,/GO,KAA,KOO,LOO,,,,, $
101  CHKPNT    GO,KAA $
102  COND      LBLM,NOMGG $
103  SMP2      USET,GO,MFF/MAA $
104  CHKPNT    MAA $
105  LABEL     LBLM $
106  COND      LBLR,NOBGG $
107  SMP2      USET,GO,BFF/BAA $
108  CHKPNT    BAA $
109  LABEL     LBLR $
110  COND      LBL5,NOK4GG $
111  SMP2      USET,GO,K4FF/K4AA $
112  CHKPNT    K4AA $
113  LABEL     LBL5 $
114  DPD       DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,DLT,PSDL,FRL,,,,
               EQDYN/V,N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,
               NOFRL/V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $
115  SAVE      LUSETD,NOUE,NODLT,NOFRL,NOPSDL $

116  EQUIV     GO,GOD/NOUE/GM,GMD/NOUE $
117  CHKPNT    USETD,EQDYN,TFPOOL,DLT,FRL,GOD,GMD,SILD,PSDL,GPLD $
118  PARAM     //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $
119  PARAM     //C,N,MPY/V,N,REPEATF/C,N,-1/C,N,1 $
120  BMG       MATPOOL,BGPDT,EQEXIN,CSTM/BDPOOL/V,N,NOKBFL/V,N,NOABFL/ V,N,
               MFACT $
121  SAVE      MFACT,NOKBFL,NOABFL $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT P

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


122  PARAM    //C,N,AND/V,N,NOFL/V,N,NOABFL/V,N,NOKBFL $
123  PURGE    KBFL/NOKBFL/ ABFL/NOABFL $
124  COND     LBLFL3,NOFL $
125  MTRXIN   ,BDPOOL,EQDYN,,/ABFL,KBFL,/V,N,LUSETO/V,N,NOABFL/V,N,NOKBFL/C,
              N,0 $
126  SAVE     NOABFL,NOKBFL $
127  LABEL    LBLFL3 $
128  CHKPNT   ABFL,KBFL $
129  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
130  JUMP     LBL13 $
                                                    Top of DMAP Loop
131  LABEL    LBL13 $
132  PURGE    QUDVC1,QUDVC2,XYPLTFA,OPPC1,EQPC1,QUPVC1,QESC1,QEPC1,QPPC2,
              QQPC2,QUPVC2,QESC2,QEPC2,XYPLTF,PSDF,AUTO,XYPLTP,   K2PP,M2PP,
              B2PP,K2DD,M2DD,B2DD/NEVER $
133  CASE     CASECC,PSDL/CASEXX/C,N,FREQ/V,N,REPEATE/V,N,NOLOOP $
134  SAVE     REPEATE,NOLOOP $
135  CHKPNT   CASEXX $
136  MTRXIN   CASEXX,MATPOOL,EQDYN,,TFPOOL/K2DPP,M2DPP,B2PP/V,N,LUSETO/V,N,
              NOK2DPP/V,N,NOM2DPP/V,N,NOB2PP $
137  SAVE     NOK2DPP,NOM2DPP,NOP2DD $
138  PARAM    //C,N,AND/V,N,NOM2PP/V,N,NOABFL/V,N,NOM2DPP $
139  PARAM    //C,N,AND/V,N,NOK2PP/V,N,NOFL /V,N,NOK2DPP $

140  EQUIV    M2DPP,M2PP/NOABFL $
141  ADD5     ABFL,KBFL,K2DPP,,/M2PP/C,N,(-1.0,0.0) $
142  COND     LBLFL2,NOABFL $
143  TRNSP    ABFL/ABFLT $
144  ADD      ABFLT,M2DPP/M2PP/V,N,PREACT $
145  LABEL    LBLFL2 $
```

```
RIGID FORMAT DMAP LISTING
SERIES F

DISPLACEMENT APPROACH, RIGID FORMAT 8

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


146  PARAM     //C,N,AND/V,N,NOFBA/V,N,NOUE/V,N,NOM2PP $

147  PARAM     //C,N,AND/V,N,KDEK2/V,N,NOGENL/V,N,NOSIMP $

148  PARAM     //C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP $

149  PURGE     K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $

150  EQUIV     M2PP,M2DD/NOA/P2PP,P2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDEMA/BAA,
               BDD/NOFBA $

151  CHKPNT    K2PP,M2PP,P2PP,K2DD,M2DD,B2DD,BDD,MDD $

152  COND      LBL1P,NOGPDT $

153  (GKAD)    USETD,GM,GO,KAA,BAA,MAA,K4AA,K2PP,M2PP,B2PP/KDD,BDD,MDD,GMD,
               GOD,K2DD,M2DD,B2DD/C,N,FREQRESP/C,N,DISP/C,N,DIRECT/C,Y,G=0.0/
               C,N,0.C/C,N,0.0/V,N,NOK2PP/V,N,NOM2PP/V,N,NOB2PP/   V,N,MPCF1/
               V,N,SINGLE/V,N,OMIT/V,N,NOUE/V,N,NOK4GG/V,N,NOBGG/V,N,KDEK2/C,
               N,-1 $

154  LABEL     LBL1E $

155  EQUIV     B2DD,BDD/NOBGG/ M2DD,MDD/NOSIMP/ K2DD,KDD/KDEK2 $

156  CHKPNT    KDD,BDD,MDD,GMD,GOD $

157  COND      ERROR1,NOFRL $

158  COND      ERROR2,NODLT $

159  (FRRD)    CASEXX,LSETD,DLT,FRL,GMD,GOD,KDD,BDD,MDD,,DIT/UDVF,PSF,PDF,PPF/
               C,N,DISP/C,N,DIRECT/V,N,LUSETD/V,N,MPCF1/V,N,SINGLE/V,N,OMIT/
               V,N,NONCUP/V,N,FRQSET $

160  EQUIV     PPF,PDF/NOSET $

161  CHKPNT    PSF,PPF,UDVF,PDF $

162  (VDR)     CASEYY,EQDYN,USETD,UDVF,PPF,XYCDB,/OUDVC1,/C,N,FREQRESP/C,N,

               DIRECT/V,N,NOSORT2/V,N,NOD/V,N,NOP/C,N,0 $

163  SAVE      NOD,NOP,NOSORT2 $

164  COND      LBL1S,NOD $

165  COND      LBL1SA,NOSORT2 $

166  CHKPNT    OUDVC1 $

167  (SDR3)    OUDVC1,,,,,/OUDVC2,,,,, $
```

```
RIGID FORMAT DMAP LISTING
SERIES

DISPLACEMENT APPROACH, RIGID FORMAT 8

    LEVEL 2.0 CASTRAN DMAP COMPILER - SOURCE LISTING


168   EFP       OUPVC2,,,,,,//V,N,CARDNO $

169   SAVE      CARDNO $

170   CHKPNT    OUPVC2 $

171   XYTRAN    XYCDB,,OUPVC2,,,,,/XYPLTFA/C,N,FREQ/C,N,DSET/V,N,PFILE/V,N,
                CARDNO $

172   SAVE      PFILE,CARDNO $

173   XYPLOT    XYPLTFA// $

174   JUMP      LBL15 $

175   LABEL     LBL15A $

176   EFP       OUPVC1,,,,,,//V,N,CARDNO $

177   SAVE      CARDNO $

178   LABEL     LBL15 $

179   COND      LBL16,NOP $

180   EQUIV     UPVF,UPVC/NOA $

181   COND      LBL19,NOA $

182   SDR1      USETD,,,LIVE,,,GOD,CMD,PSF,KFS,,/UPVC,,OPC/C,N,1/C,N,DYNAMICS $

183   LABEL     LBL19 $

184   CHKPNT    UPVC,OPC $

185   SDR2      CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,,PPF,OPC,UPVC,EST,XYCDB,PPF/
                OPPC1,OOPC1,OLPVC1,OESC1,OEFC1,/C,N,FREQRESP/V,N,NOSORT2 $

186   SAVE      NOSORT2 $


187   COND      LBL17,NOSORT2 $

188   SDR3      OPPC1,OOPC1,OUPVC1,OESC1,OEFC1,/OPPC2,OOPC2,OUPVC2,OESC2,
                OEFC2, $

189   CHKPNT    OPPC2,OOPC2,OUPVC2,OESC2,OEFC2 $

190   EFP       OEFC2,OOPC2,OUPVC2,OEFC2,OESC2,//V,N,CARDNO $

191   SAVE      CARDNO $

192   XYTRAN    XYCDB,OPPC2,OOPC2,OUPVC2,OESC2,OEFC2/XYPLTF/C,N,FREQ/C,N,PSET/
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 8

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

                V,N,PFILE/V,N,CARDNO $
193  SAVE       PFILE,CARDNO $
194  XYPLOT     XYPLTF// $
195  COND       LBL16,NOPSDL $
196  RANDOM     XYCDB,DIT,PSDL,OUPVC2,OPPC2,OQPC2,OESC2,OEFC2,CASEXX/PSDF,AUTO/
                V,N,NORD $
197  SAVE       NORD $
198  CHKPNT     PSDF,AUTO $
199  COND       LBL16,NORD $
200  XYTRAN     XYCDB,PSDF,AUTO,,,,/XYPLTR/C,N,RAND/C,N,PSET/V,N,PFILE/   V,N,
                CARDNO $
201  SAVE       PFILE,CARDNO $
202  XYPLOT     XYPLTR// $
203  JUMP       LBL16 $
204  LABEL      LBL17 $
205  OFP        OUPVC1,OPPC1,OQPC1,OEFC1,OESC1,//V,N,CARDNO $
206  SAVE       CARDNO $
207  LABEL      LBL16 $
208  COND       FINIS,REPEATF $
209  REPT       LBL13,100 $                          Bottom of DMAP Loop
210  JUMP       ERROR3 $
211  JUMP       FINIS $

212  LABEL      ERROR3 $
213  PRTPARM    //C,N,-3/C,N,DIRFRRD $
214  LABEL      ERROR2 $
215  PRTPARM    //C,N,-2/C,N,DIRFRRD $
216  LABEL      ERROR1 $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 8

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


217  PRTPARM  //C,N,-1/C,N,DIRERRD $

218  LABEL    ERROR4 $

219  PRTPARM  //C,N,-4/C,N,DIRERRD $

220  LABEL    FINIS $

221  END      $
```

2. Nonzero components of the applied load vector and single-point forces of constraint for a list of PHYSICAL points.
3. Stresses and forces in selected elements (ALL available only for SØRT1).

The following plotter output is available for Frequency Response calculations:

1. Undeformed plot of the structural model.
2. X-Y plot of any component of displacement, velocity, or acceleration of a PHYSICAL point or SØLUTIØN point.
3. X-Y plot of any component of the applied load vector or single-point force of constraint.
4. X-Y plot of any stress or force component for an element.

The following plotter output is available for Random Response calculations:

1. X-Y plot of the power spectral density versus frequency for the response of selected components for points or elements.
2. X-Y plot of the autocorrelation versus time lag for the response of selected components for points or elements.

The data used for preparing the X-Y plots may be punched or printed in tabular form (see Section 4.3). This is the only form of printed output that is available for Random Response. Also, a printed summary is prepared for each X-Y plot which includes the maximum and minimum values of the plotted function.

The following parameters are used in Frequency Response calculations:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.
2. WTMASS - optional - the terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

3. G - optional - the real value of this parameter is used as a uniform structural damping coefficient in the direct formulation of dynamics problems. Not recommended for use in hydroelastic problems.

4. COUPMASS - CPBAR, CPROD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

3.9.4 Automatic Alters for Automated Multi-stage Substructuring

The following lines of the Direct Frequency and Random Response Analysis, Rigid Format 8, are altered in automatic substructure analyses.

Phase 1: 2, 72, 114-158, 159-210
Phase 2: 2, 3-4, 12-23, 28-30, 54-65, 147-148, 155-155, 180-206
Phase 3: 113, 118-181, 184, 208-210

If APP DISP, SUBS is used, the user may also specify ALTERs. However, these must not interfere with the automatically generated DMAP statement ALTERs listed above. See Section 5.9 for a description and listing of the ALTERs which are automatically generated for substructuring.

3.10 DIRECT TRANSIENT RESPONSE

3.10.1 DMAP Sequence for Direct Transient Response

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 9

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN    NO.9 DIRECT TRANSIENT RESPONSE ANALYSIS - SERIES P $

    2  FILE     KGGX=TAPE/KGG=TAPE/UDVT=APPEND/TOL=APPEND $

    3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT $

    4  SAVE     LUSET,NOGPDT $

    5  PURGE    USET,GM,GO,KAA,BAA,MAA,K4AA,PST,KFS,OP,EST,ECT,PLTSETX,PLTPAR,
                GPSETS,ELSETS/NOGPDT $

    6  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL,USET,GM,GO,KAA,BAA,MAA,K4AA,
                PST,KFS,OP,EST,ECT,PLTSETX,PLTPAR,GPSETS,ELSETS $

    7  COND     LBL5,NOGPDT $

    8  GP2      GEOM2,EQEXIN/ECT $

    9  CHKPNT   ECT $

   10  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

   11  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

   12  COND     P1,NOPCDB $

   13  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
                JUMPPLOT=-1 $

   14  SAVE     NSIL,JUMPPLOT $

   15  PRTMSG   PLTSETX// $

   16  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

   17  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $


   18  COND     P1,JUMPPLOT $

   19  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

   20  SAVE     JUMPPLOT,PLTFLG,PFILE $

   21  PRTMSG   PLOTX1// $

   22  LABEL    P1 $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 9

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


23   CHKPNT    PLTPAR,GPSETS,ELSETS $

24   GP3       GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $

25   CHKPNT    SLT,GPTT $

26   TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,,,/V,N,LUSET/V,N,
               NOSIMP=-1/C,N,1/V,N,NOGENL=-1/V,N,GENEL $

27   SAVE      NOSIMP,NOGENL,GENEL $

28   PURGE     K4GG,GPST,OGPST,MGG,BGG,  K4NN,K4FF,K4AA,MNN,MFF,MAA,BNN,BFF,
               BAA,KGGX/NOSIMP/ OGPST/GENEL $

29   CHKPNT    EST,GPECT,GEI,K4GG,GPST,MGG,BGG,KGGX,OGPST,  K4NN,K4FF,K4AA,
               MNN,MFF,MAA,BNN,BFF,BAA $

30   COND      LBL1,NOSIMP $

31   PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

32   PARAM     //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

33   PARAM     //C,N,ADD/V,N,NOBGG=-1/C,N,1/C,N,0 $

34   PARAM     //C,N,ADD/V,N,NOK4GG/C,N,1/C,N,0 $

35   EMG       EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,BELM,BDICT/   V,
               N,NOKGGX/V,N,NOMGG/V,N,NOBGG/V,N,NOK4GG/C,N,/C,Y,COUPMASS/C,Y,
               CPBAR/C,Y,CPROD/C,Y,CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,
               CPTRIA2/C,Y,CPTUBE/C,Y,CPODPLT/C,Y,CPTRPLT/C,Y,CPTRPSC $

36   SAVE      NOKGGX,NOMGG,NOBGG,NOK4GG $

37   CHKPNT    KELM,KDICT,MELM,MDICT,BELM,BDICT $

38   COND      LBLKGGX,NOKGGX $

39   EMA       GPECT,KDICT,KELM/KGGX,GPST $


40   CHKPNT    KGGX,GPST $

41   LABEL     LBLKGGX $

42   COND      LBLMGG,NOMGG $

43   EMA       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

44   CHKPNT    MGG $

45   LABEL     LBLMGG $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 2

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


46  COND      LBLBGG,NOBGG $
47  (EMA)     GPECT,BDICT,BELM/BGG, $
48  CHKPNT    BGG $
49  LABEL     LBLBGG $
50  COND      LBLK4GG,NOK4GG $
51  (EMA)     GPECT,KDICT,KELM/K4GG,/V,N,NOK4GG $
52  CHKPNT    K4GG $
53  LABEL     LBLK4GG $
54  PURGE     MNN,MEE,MAA/NOMGG $
55  PURGE     BNN,BEE,BAA/NOBGG $
56  CHKPNT    MGG,MNN,MEE,MAA,BGG,BNN,BEE,BAA $
57  COND      LBL1,GRDPNT $
58  COND      ERROR3,NOMGG $
59  (GPWG)    BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $
60  OFP       OGPWG,,,,,// $
61  LABEL     LBL1 $
62  EQUIV     KGGX,KGG/NOGENL $
63  CHKPNT    KGG $
64  COND      LBL11,NOGENL $
65  (SMA3)    GET,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $


66  CHKPNT    KGG $
67  LABEL     LBL11 $
68  PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
69  (GP4)     CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,LUSET/
              V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
              N,REPEAT/V,N,NOSET/V,N,NCL/V,N,NOA/C,Y,SUBID $
70  SAVE      MPCF1,SINGLE,OMIT,NOSET,REACT,MPCF2,NSKIP,REPEAT,NOL,NOA $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 9

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


71  PURGE    GM,GMD/MPCF1/GO,GOD/OMIT/KFS,PST,OP/SINGLE $
72  CHKPNT   GM,GMD,RG,GO,GOD,KFS,PST,OP,USET $
73  COND     LBL4,GENEL $
74  COND     LBL4,NOSIMP $
75  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
76  SAVE     NOGPST $
77  COND     LBL4,NOGPST $
78  OFP      OGPST,,,,,// $
79  LABEL    LBL4 $
80  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1/ BGG,BNN/MPCF1/K4GG,K4NN/MPCF1 $
81  CHKPNT   KNN,MNN,BNN,K4NN $
82  COND     LBL2,MPCF1 $
83  MCE1     USET,RG/GM $
84  CHKPNT   GM $
85  MCF2     USET,GM,KGG,MGG,BGG,K4GG/KNN,MNN,BNN,K4NN $
86  CHKPNT   KNN,MNN,BNN,K4NN $
87  LABEL    LBL2 $
88  EQUIV    KNN,KFF/SINGLE/MNN,MFF/SINGLE/BNN,BFF/SINGLE/K4NN,K4FF/SINGLE $
89  CHKPNT   KFF,MFF,BFF,K4FF $
90  COND     LBL3,SINGLE $

91  SCE1     USET,KNN,MNN,BNN,K4NN/KFF,KFS, ,MFF,BFF,K4FF $
92  CHKPNT   KFS,KFF,MFF,BFF,K4FF $
93  LABEL    LBL3 $
94  EQUIV    KFF,KAA/OMIT $
95  EQUIV    MFF,MAA/OMIT $
96  EQUIV    BFF,BAA/OMIT $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 9

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


 97  EQUIV     K4FF,K4AA/OMIT $
 98  CHKPNT    KAA,MAA,BAA,K4AA $
 99  COND      LBL5,OMIT $
100  (SMP1)    USET,KFF,,,,/GO,KAA,KOO,LOO,,,,, $
101  CHKPNT    GO,KAA $
102  COND      LBLM,NOMGG $
103  (SMP2)    USET,GO,MFF/MAA $
104  CHKPNT    MAA $
105  LABEL     LBLM $
106  COND      LBLB,NOBGG $
107  (SMP2)    USET,GO,BFF/BAA $
108  CHKPNT    BAA $
109  LABEL     LBLB $
110  COND      LBL5,NOK4GG $
111  (SMP2)    USET,GO,K4FF/K4AA $
112  CHKPNT    K4AA $
113  LABEL     LBL5 $
114  (DPD)     DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,DLT,,,NLFT,TRL,,
               EQDYN/V,N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/  V,
               N,NOFRL/V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $
115  SAVE      LUSETD,NODLT,NONLFT,NOTRL,NOUE $

116  PURGE     PNLD/NONLFT$
117  EQUIV     GO,GOD/NOUE/GM,GMD/NOUE $
118  CHKPNT    USETD,EQDYN,TFPOOL,DLT,TRL,GOD,GMD,NLFT,PNLD,SILD,GPLD $
119  (BMG)     MATPOOL,BGPDT,EQEXIN,CSTM/BDPOOL/V,N,NOKBFL/V,N,NOABFL/ V,N,
               MFACT $
120  SAVE      MFACT,NOKBFL,NOABFL $
121  PARAM     //C,N,AND/V,N,NOFL/V,N,NOABFL/V,N,NOKBFL $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 9

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


122  PURGE    KAFL/NOKAFL/ AAFL/NOAAFL $
123  COND     LALFL3,NOFL $
124  MTRXIN,  ,BGPOOL,EQDYN,,,/AAFL,KAFL,,/V,N,LUSETD/V,N,NOAAFL/V,N,NOKAFL/C,
              N,0 $
125  SAVE     NOAAFL,NOKAFL $
126  LABEL    LALFL3 $
127  CHKPNT   AAFL,KAFL $
128  MTRXIN   CASECC,MATPOOL,EQDYN,,,TEPOOL/K2DPP,M2DPP,B2PP/V,N,LUSETD/V,N,
              NOK2DPP/V,N,NOM2DPP/V,N,NOB2PP $
129  SAVE     NOK2DPP,NOM2DPP,NOB2PP $
130  PARAM    //C,N,AND/V,N,NOM2PP/V,N,NOAAFL/V,N,NOM2DPP $
131  PARAM    //C,N,AND/V,N,NOK2PP/V,N,NOFL /V,N,NOK2DPP $
132  EQUIV    M2DPP,M2PP/NOAAFL $
133  ADD5     AAFL,KAFL,K2DPP,,,/K2PP/C,N,(-1.0,0.0) $
134  COND     LALFL2,NOAAFL $
135  TRNSP    AAFL/AAFLT $
136  ADD      AAFLT,M2DPP/M2PP/V,N,MFACT $
137  LABEL    LALFL2 $
138  PARAM    //C,N,AND/V,N,KDFKA/V,N,NOUE/V,N,NOK2PP $
139  PARAM    //C,N,AND/V,N,MDFMA/V,N,NOUE/V,N,NOM2PP $
140  PARAM    //C,N,AND/V,N,KDFK2/V,N,NOGENL/V,N,NOSIMP $


141  PURGE    K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $
142  EQUIV    K2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDFMA/ KAA,
              KDD/KDFKA $
143  CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,MDD,KDD $
144  COND     LAL16,NOGPDT $
145  GKAD     USETD,GM,CC,KAA,BAA,MAA,K4AA,K2PP,M2PP,B2PP/KDD,BDD,MDD,GMD,
              GOD,K2DD,M2DD,B2DD/C,N,TRANSFSP/C,N,DISP/C,N,DIRECT/C,Y,G=0.0/
              C,Y,W3=0.0/C,Y,W4=0.0/V,N,NOK2PP/V,N,NOM2PP/V,N,NOB2PP/ V,N,
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 9

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

            MPCF1/V,N,SINGLE/V,N,OMIT/V,N,NOUE/V,N,NOK4GG/V,N,NOMGG/V,N,
            KDEK2/C,N,-1 $
146 LABEL   LBL16 $
147 EQUIV   M2DD,MDD/NOSIMP/B2DD,BDD/NOGPDT/K2DD,KDD/KDEK2 $
148 CHKPNT  KDD,BDD,MDD,GMD,GOD $
149 COND    ERROR1,NOTRL $
150 PARAM   //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $
151 PARAM   //C,N,MPY/V,N,REPEATT/C,N,1/C,N,-1 $
152 PARAM   //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
153 JUMP    LBL13 $
                                                  Top of DMAP Loop
154 LABEL   LBL13 $
155 PURGE   PNLD,OUDV1,OPNL1,OUDV2,OPNL2,XYPLTTA,OPP1,OQP1,OUPV1,OES1,OEF1,
            OPP2,OQP2,OUPV2,OES2,OEF2,PLOTX2,XYPLTT/NEVER $
156 CASE    CASECC,/CASEXX/C,N,TRAN/V,N,REPEATT/V,N,NOLOOP $
157 SAVE    REPEATT,NOLOOP $
158 CHKPNT  CASEXX $
159 PARAM   //C,N,MPY/V,N,NCOL/C,N,0/C,N,1 $
160 TRLG    CASEXX,USETD,DLT,SLT,BGPDT,SIL,CSTM,TRL,DIT,GMD,GOD,,EST,MGG/
            PPT,PST,PDT,PD,,TOL/V,N,NOSET/V,N,PDEPDD/V,N,NCOL $
161 SAVE    PDEPDD,NOSET $
162 CHKPNT  PPT,PST,PDT,PD,TOL $
163 EQUIV   PD,PDT/PDEPDD/PPT,PDT/NOSET $

164 CHKPNT  PDT $
165 TRD     CASEXX,TRL,NLFT,DIT,KDD,BDD,MDD,PD/UDVT,PNLD/C,N,DIRECT/V,N,
            NOUE/V,N,NONCUP/V,N,NCOL/C,Y,ISTART $
166 SAVE    NCOL $
167 CHKPNT  UDVT,PNLD $
168 VDR     CASEXX,EQDYN,USETD,UDVT,TOL,YYCDB,PNLD/OUDV1,OPNL1/ C,N,
            TRANRESP/C,N,DIRECT/C,N,0/V,N,NOD/V,N,NOP/C,N,0 $
```

```
RIGID FORMAT DMAP LISTING
SERIES 9

DISPLACEMENT APPROACH, RIGID FORMAT 9

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


169  SAVE      NOD,NOF $
170  CHKPNT    OUDV1,OPNL1 $
171  COND      LBL15,NOD $
172  SDR3      OUDV1,OPNL1,,,,/OUDV2,OPNL2,,,, $
173  OFP       OUDV2,OPNL2,,,,//V,N,CARDNO $
174  SAVE      CARDNO $
175  CHKPNT    OPNL2,OUDV2 $
176  XYTRAN    XYCDB,OUDV2,OPNL2,,,/XYPLTTA/C,N,TRAN/C,N,DSET/V,N,PFILE/V,N,
               CARDNO $
177  SAVE      PFILE,CARDNO $
178  XYPLOT    XYPLTTA// $
179  LABEL     LBL15 $
180  PARAM     //C,N,AND/V,N,PJUMP/V,N,NOP/V,N,JUMPPLOT $
181  COND      LBL18,PJUMP $
182  EQUIV     UDVT,UPV/NOA $
183  COND      LBL17,NOA $
184  SDR1      USETD,,UDVT,,,CCD,GMD,PST,KFS,,/UPV,,OP/C,N,1/C,N,DYNAMICS $
185  LABEL     LBL17 $
186  CHKPNT    UPV,OP $
187  SDR2      CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,BGPDT,TOL,OP,UPV,EST,XYCDB,
               PPT/OPP1,OOP1,OUPV1,OES1,OEF1,PUGV/C,N,TRANRESP $


188  SDR3      OPP1,OOP1,OUPV1,OES1,OEF1,/OPP2,OOP2,OUPV2,OES2,OEF2, $
189  CHKPNT    OPP2,OOP2,OUPV2,OES2,OEF2 $
190  OFP       OPP2,OOP2,OUPV2,OEF2,OES2,//V,N,CARDNO $
191  SAVE      CARDNO $
192  COND      P2,JUMPPLOT $
193  PLOT      PLTPAR,GPSETS,ELSETS,CASEXX,BGPDT,EQEXIN,SIL,,PUGV,GPECT,OES1/
               PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 9.

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


194  SAVE     PFILE $
195  PRTMSG   PLOTX2// $
196  LABEL    P2 $
197  XYTRAN   XYCDB,OPP2,OQP2,OUPV2,OES2,OEF2/XYPLTT/C,N,TRAN/C,N,PSET/V,N,
              PFILE/V,N,CARDNO $
198  SAVE     PFILE,CARDNO $
199  XYPLOT   XYPLTT// $
200  LABEL    LBL18 $
201  COND     FINIS,REPEATT $
202  REPT     LBL13,100 $
203  JUMP     ERROR2 $
204  JUMP     FINIS $
205  LABEL    ERROR2 $
206  PRTPARM  //C,N,-2/C,N,DIPTRD $
207  LABEL    ERROR1 $
208  PRTPARM  //C,N,-1/C,N,DIPTRD $
209  LABEL    ERROR3 $
210  PRTPARM  //C,N,-3/C,N,DIPTRD $
211  LABEL    FINIS $
212  END      $
```

Bottom of DMAP Loop

3.10.2 Description of DMAP Operations for Direct Transient Response

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

7. Go to DMAP No. 113 if only Direct Matrix Input.

8. GP2 generates Element Connection Table with internal indices.

12. Go to DMAP No. 22 if no plot output is requested.

13. PLTSET transforms user input into a form used to drive structure plotter.

15. PRTMSG prints error messages associated with structure plotter.

18. Go to DMAP No. 22 if no undeformed structure plots are requested.

19. PLØT generates all requested undeformed structure plots.

21. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

24. GP3 generates Grid Point Temperature Table.

26. TA1 generates element tables for use in matrix assembly and stress recovery.

30. Go to DMAP No. 61 if there are no structural elements.

35. EMG generates structural element stiffness, mass, and damping matrix tables and dictionaries for later assembly.

38. Go to DMAP No. 41 if no stiffness matrix is to be assembled.

39. EMA assembles stiffness matrix $[K^{x}_{gg}]$ and Grid Point Singularity Table.

42. Go to DMAP No. 45 if no mass matrix is to be assembled.

43. EMA assembles mass matrix $[M_{gg}]$.

46. Go to DMAP No. 49 if no viscous damping matrix is to be assembled.

47. EMA assembles viscous damping matrix $[B_{gg}]$.

50. Go to DMAP No. 53 if no structural damping matrix is to be assembled.

51. EMA assembles structural damping matrix $[K4_{gg}]$.

57. Go to DMAP No. 61 if no weight and balance is requested.

58. Go to DMAP No. 209 and print error message if no mass matrix exists.

59. GPWG generates weight and balance information.

60. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

62. Equivalence $[K^{x}_{gg}]$ to $[K_{gg}]$ if no general elements.

64. Go to DMAP No. 67 if no general elements.

65. SMA3 adds general elements to $[K^{x}_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

69. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

73. Go to DMAP No. 79 if general elements present.

74. Go to DMAP No. 79 if no structural elements.

114. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers (GPLD), including extra points introduced for dyanmic analysis (SILD), and prepares Transfer Function Pool (TFPØØL), Dynamics Load Table (DLT), Nonlinear Function Table (NLFT), and Transient Response List (TRL).

117. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

119. BMG generates DMIG card images describing the interconnection of the fluid and the structure.

123. Go to DMAP No. 126 if no fluid structure interface is defined.

124. MTRXIN generates fluid boundary matrices $[A_{b,f\ell}]$ and $[K_{b,f\ell}]$ if a fluid structure interface is defined. The matrix $[K_{b,f\ell}]$ is generated only for a nonzero gravity in the field.

128. MTRXIN selects the direct input matrices $[K_{pp}^{2d}]$, $[M_{pp}^{2d}]$ and $[B_{pp}^{2}]$.

132. Equivalence $[M_{pp}^{2d}]$ to $[M_{pp}^{2}]$ if no $[A_{b,f\ell}]$.

133. ADD5 adds $[K_{b,f\ell}]$ and $[K_{pp}^{2d}]$ and subtracts $[A_{b,f\ell}]$ from them to form $[K_{pp}^{2}]$.

134. Go to DMAP No. 137 if no $[A_{b,f\ell}]$.

135. Transpose $[A_{b,f\ell}]$ to obtain $[A_{b,f\ell}]^T$.

136. ADD assembles input matrix $[M_{pp}^{2}] = \text{MFACT}\ [A_{b,f\ell}]^T + [M_{pp}^{2d}]$.

142. Equivalence $[M_{pp}^{2}]$ to $[M_{dd}^{2}]$, $[B_{pp}^{2}]$ to $[B_{dd}^{2}]$ and $[K_{pp}^{2}]$ to $[K_{dd}^{2}]$ if no constraints applied, $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points, and $[K_{aa}]$ to $[K_{dd}]$ if no direct input stiffness matrices and no extra points.

144. Go to DMAP No. 146 if only extra points defined.

145. GKAD assembles stiffness, mass, and damping matrices for use in Direct Transient Response

$$[K_{dd}] = [K_{dd}^{1}] + [K_{dd}^{2}],$$

$$[M_{dd}] = [M_{dd}^{1}] + [M_{dd}^{2}],$$

and

$$[B_{dd}] = [B_{dd}^{1}] + [B_{dd}^{2}] + \frac{g}{\omega_3}[K_{dd}^{1}] + \frac{1}{\omega_4}[K_{dd}^{4}],$$

where

$$\begin{bmatrix} K_{aa} & 0 \\ 0 & 0 \end{bmatrix} \Rightarrow [K_{dd}^{1}],$$

$$\begin{bmatrix} M_{aa} & 0 \\ 0 & 0 \end{bmatrix} \Rightarrow [M_{dd}^{1}],$$

$$\begin{bmatrix} B_{aa} & 0 \\ 0 & 0 \end{bmatrix} \Rightarrow [B_{dd}^{1}],$$

and $$\begin{bmatrix} K^4_{aa} & 0 \\ 0 & 0 \end{bmatrix} \Rightarrow [K^4_{dd}].$$

All matrices are real.

147. Equivalence $[B^2_{dd}]$ to $[B_{dd}]$ if all damping is Direct Matrix Input, $[M^2_{dd}]$ to $[M_{dd}]$ if all mass is Direct Matrix Input and $[K^2_{dd}]$ to $[K_{dd}]$ is all stiffness is Direct Matrix Input.

149. Go to DMAP No. 207 and print error message if no Transient Response List.

153. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

154. Beginning of loop for additional dynamic load sets.

156. CASE extracts user requests from CASECC for current loop.

160. TRLG generates matrices of loads versus time. $\{P^t_p\}$, $\{P^t_s\}$, and $\{P^t_d\}$ are generated with one column per output time step. $\{P_d\}$ is generated with one column per solution time step, and the Transient Output List (TØL) is a list of output time steps.

163. Equivalence $\{P_d\}$ to $\{P^t_d\}$ if the output times are the same as the solution times and $\{P^t_p\}$ to $\{P^t_d\}$ if the d and p sets are the same.

165. TRD forms the linear, $\{P_d\}$, and nonlinear, $\{P^{n\ell}_d\}$, dynamic load vectors and integrates the equations of motion (using the standard starting procedure) over specified time periods to solve for the displacements, velocities, and accelerations, using the following equation

$$[M_{dd}p^2 + B_{dd}p + K_{dd}]\{u_d\} = \{P_d\} + \{P^{n\ell}_d\} \quad .$$

168. VDR prepares displacements, velocities and accelerations, sorted by time step, for output using only the independent degrees of freedom.

171. Go to DMAP No. 179 if no output request for the independent degrees of freedom.

172. SDR3 prepares requested output of the independent displacements, velocities, accelerations and nonlinear load vectors sorted by point number or element number.

173. ØFP formats tables prepared by SDR3 sorted by point number or element number and places them on the system output file for printing.

176. XYTRAN prepares the input for X-Y plotting of the independent displacements, velocities, accelerations and nonlinear load vectors vs. time.

178. XYPLØT prepares requested X-Y plots of the independent displacements, velocities, accelerations and nonlinear load vectors vs. time.

181. Go to DMAP No. 200 if no output request involving dependent degrees of freedom or forces and stresses.

182. Equivalence $\{u_d\}$ to $\{u_p\}$ if no constraints applied.

183. Go to DMAP No. 185 if no constraints applied.

5. X-Y plot of any component of the applied load vector, nonlinear force vector, or single-point force of constraint.

6. X-Y plot of any stress or force component for an element.

The data used for preparing the X-Y plots may be punched or printed in tabular form (see Section 4.2). Also, a printed summary is prepared for each X-Y plot which includes the maximum and minimum values of the plotted function.

The following parameters are used in Direct Transient Response:

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

3. G - optional - The real value of this parameter is used as a uniform structural damping coefficient in the direct formulation of dynamics problems. Not recommended for use in hydroelastic problems.

4. W3 and W4 - optional - The values of these parameters are used as pivotal frequencies for uniform structural damping and element structural damping respectively. W3 is required if uniform structural damping is desired. W4 is required if structural damping is desired for any of the structural elements. See page 9.3-8 of the NASTRAN Theoretical Manual.

5. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - These parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

6. ISTART - optional - A positive value of this parameter will cause the TRD module to use the second (or alternate) starting method (see Section 11.3 of the Theoretical Manual). The alternate starting method is recommended when initial accelerations are significant and when the mass matrix is non-singular.

3.10.4 The CONTINUE Feature

In transient analysis, it is frequently necessary to continue the integration of the coup. equations beyond the last (or from any earlier intermediate) output time for which the solution was obtained in a previous run. The CONTINUE feature (see Section 11.3.2 of the Theoretical Manual for details) makes it possible to do this without re-executing the entire problem.

In order to use the CONTINUE feature, the user should employ the following steps:

1. Request a checkpoint of a coupled transient analysis problem.
2. Check to ensure that the solution for at least one output time is computed in this run and that the TØL (list of output times) and UDVT (displacement - velocity - acceleration) files are successfully checkpointed.
3. Restart the problem by changing any one or more of several cards either in the Case Control Deck (DLØAD, NØNLINEAR, TSTEP cards) and/or in the Bulk Data Deck (TSTEP, DAREA, DLØAD, FØRCE, etc.) that define either the dynamic loading and/or the time step selection. Ensure that the following conditions are satisfied.
 a. The structural model and the constraint data for the restart must be the same as that used in the checkpoint run.
 b. The dynamic loading and/or the time step selection in the restart need not be the same as that used in the checkpoint run.
 c. If the user wishes to continue the integration from an intermediate (rather than from the last) output time of the checkpoint run, a DMAP alter should be employed in the Executive Control Deck to reset the parameter NCØL to the appropriate value by means of a PARAM statement just before the TRLG module in the DMAP sequence. (See Section 11.3.2 of the Theoretical Manual for details).
4. Note that the output of the restart does not include the solutions of the checkpoint run, but only those solutions that are computed by the restart. Also, any initial conditions specified in the data for the restart are ignored since the solution is continued by using the displacements, velocities and accelerations corresponding to the specified output time of the checkpoint run as initial conditions.

3.10.5 Automatic Alters for Automated Multi-stage Substructuring

The following lines of the Direct Transient Response Analysis, Rigid Format 9, are altered in automatic substructure analyses.

Phase 1: 2, 72, 114-164, 165-203
Phase 2: 2, 3-4, 12-23, 28-30, 54-65, 139-140, 147-147, 182-199
Phase 3: 113, 119-183, 186, 201-203

If APP DISP, SUBS is used, the user may also specify ALTERs. However, these must not interfere with the automatically generated DMAP statement ALTERs listed above. See Section 5.9 for a description and listing of the ALTERs which are automatically generated for substructuring.

3.11 MODAL COMPLEX EIGENVALUE ANALYSIS

3.11.1 DMAP Sequence for Modal Complex Eigenvalue Analysis

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 10

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      EPR=2   NOLIST  NODECK  NOREF   NOOSCAR

     1  BEGIN    NO.10 MODAL COMPLEX EIGENVALUE ANALYSIS - SERIES P $

     2  FILE     GOD=SAVE/ GMD=SAVE/ LAMA=APPEND/ PHIA=APPEND $

     3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                 NOGPDT $

     4  SAVE     LUSET $

     5  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

     6  GP2      GEOM2,EQEXIN/ECT $

     7  CHKPNT   ECT $

     8  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

     9  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

    10  COND     P1,NOPCDB $

    11  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,N
                 JUMPPLOT=-1 $

    12  SAVE     NSIL,JUMPPLOT $

    13  PRTMSG   PLTSETX// $

    14  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

    15  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

    16  COND     P1,JUMPPLOT $

    17  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                 NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

    18  SAVE     PFILE $


    19  PRTMSG   PLOTX1// $

    20  LABEL    P1 $

    21  CHKPNT   PLTPAR,GPSETS,ELSETS $

    22  GP3      GEOM3,EQEXIN,GEOM2/,CPTT/V,N,NOGRAV $

    23  CHKPNT   CPTT $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 10

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


24   TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,,,/V,N,LUSET/V,N,
              NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

25   SAVE     NOGENL,NOSIMP,GENEL $

26   COND     ERROR1,NOSIMP $

27   PURGE    OGPST/GENEL $

28   CHKPNT   EST,GPECT,GEI,OGPST $

29   PARAM    //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

30   PARAM    //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

31   EMG      EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
              N,NOMGG/C,N, /C,N, /C,N, /C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
              CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
              CPODPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

32   SAVE     NOKGGX,NOMGG $

33   CHKPNT   KELM,KDICT,MELM,MDICT $

34   COND     JMPKGGX,NOKGGX $

35   EMA      GPECT,KDICT,KELM/KGGX,GPST $

36   CHKPNT   KGGX,GPST $

37   LABEL    JMPKGGX $

38   COND     ERROR1,NOMGG $

39   EMA      GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

40   CHKPNT   MGG $

41   COND     LGPWG,GRDPNT $


42   GPWG     BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $

43   OFP      OGPWG,,,,,// $

44   LABEL    LGPWG $

45   EQUIV    KGGX,KGG/NOGENL $

46   CHKPNT   KGG $

47   COND     LBL11,NOGENL $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 10

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


48  SMA3      GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
49  CHKPNT    KGG $
50  LABEL     LBL11 $
51  PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
52  GP4       CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,LUSET/
              V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
              N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
53  SAVE      MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2,NSKIP,REPEAT,NOL,NOA $
54  PARAM     //C,N,AND/V,N,NOSR/V,N,REACT/V,N,SINGLE $
55  PURGE     GM,GMD/MPCF1/GO,GOD/OMIT/KFS/SINGLE/QPC/NOSR/KLR,KRR,MLR,MRR,
              DM,MR/REACT $
56  CHKPNT    KRR,KLR,DM,MLR,MRR,MR,GM,PG,GO,KFS,QPC,USET,GMD,GOD,ASET $
57  COND      LBL4,GENEL $
58  GPSP      GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
59  SAVE      NOGPST $
60  COND      LBL4,NOGPST $
61  OFP       OGPST,,,,,// $
62  LABEL     LBL4 $
63  EQUIV     KGG,KNN/MPCF1/MGG,MNN/MPCF1 $
64  CHKPNT    KNN,MNN $
65  COND      LBL2,MPCF1 $
66  MCF1      USET,RG/GM $

67  CHKPNT    GM $
68  MCE2      USET,GM,KGG,MGG,,/KNN,MNN,, $
69  CHKPNT    KNN,MNN $
70  LABEL     LBL2 $
71  EQUIV     KNN,KFF/SINGLE/MNN,MFF/SINGLE $
72  CHKPNT    KFF,MFF $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 10

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


73  COND      LBL3,SINGLE $
74  SCE1      USET,KNN,MNN,,,/KFF,KFS,,MFF,, $
75  CHKPNT    KFS,KFF,MFF $
76  LABEL     LBL3 $
77  EQUIV     KFF,KAA/OMIT $
78  EQUIV     MFF,MAA/OMIT $
79  CHKPNT    KAA,MAA $
80  COND      LBL5,OMIT $
81  SMP1      USET,KFF,,,,/GO,KAA,KOO,LOO,,,,, $
82  CHKPNT    GO,KAA $
83  SMP2      USET,GO,MFF/MAA $
84  CHKPNT    MAA $
85  LABEL     LBL5 $
86  COND      LBL6,REACT $
87  RBMG1     USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $
88  CHKPNT    KLL,KLR,KRR,MLL,MLR,MRR $
89  RBMG2     KLL/LLL $
90  CHKPNT    LLL $
91  RBMG3     LLL,KLR,KRR/DM $
92  CHKPNT    DM $

93  RBMG4     DM,MLL,MLR,MRR/MR $
94  CHKPNT    MR $
95  LABEL     LBL6 $
96  DPD       DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,,,,,,EED,EQDYN/V,
              N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/V,
              N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $
97  SAVE      LUSETD,NOUE,NOEED $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 10

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


 98  COND      ERROR2,NOEED $
 99  EQUIV     GO,GOD/NOUE/GM,GMD/NOUE $
100  CHKPNT    USETD,EED,EQDYN,TEPOOL,GOD,GMD,SILD,GPLD $
101  PARAM     //C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 $
102  READ      KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N,
               NEIGV $
103  SAVE      NEIGV $
104  CHKPNT    LAMA,PHIA,MI,OEIGS $
105  PARAM     //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
106  OFP       OEIGS,,,,,//V,N,CARDNO $
107  SAVE      CARDNO $
108  COND      ERROR4,NEIGV $
109  OFP       LAMA,,,,,//V,N,CARDNO $
110  SAVE      CARDNO $
111  PARAM     //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $
112  PARAM     //C,N,MPY/V,N,REPEATE/C,N,1/C,N,-1 $
113  JUMP      LBL13 $
                                                          Top of DMAP Loop
114  LABEL     LBL13 $
115  PURGE     PHIH,CLAMA,OPHIH,CPHID,CPHIP,OPC,OOPC1,OCPHIP,OESC1,OEFC1,K2PP,
               M2PP,B2PP,K2DD,M2DD,B2DD/NEVER $
116  CASE      CASECC,/CASEXX/C,N,CEIGN/V,N,REPEATE/V,N,NOLOOP $

117  SAVE      REPEATE,NOLOOP $
118  CHKPNT    CASEXX $
119  MTRXIN    CASEXX,MATPOOL,EQDYN,,TEPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N,
               NOK2PP/V,N,NOM2PP/V,N,NOB2PP $
120  SAVE      NOK2PP,NOM2PP,NOB2PP $
121  PURGE     K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $
122  EQUIV     M2PP,M2DD/NOSET/B2PP,B2DD/NOSET/K2PP,K2DD/NOSET $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 10

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


123  CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD $

124  GKAD     USETD,GM,GO,,,,,K2PP,M2PP,B2PP/,,,GMD,GOD,K2DD,M2DD,B2DD/C,N,
              CMPLEV/C,N,DISP/C,N,MODAL/C,N,0.0/C,N,0.0/C,N,0.0/V,N,NOK2PP/V,
              N,NOM2PP/V,N,NOB2PP/   V,N,MPCF1/V,N,SINGLE/V,N,OMIT/V,N,NOUE/
              C,N,-1/C,N,-1/   C,N,-1/C,N,-1 $

125  CHKPNT   K2DD,M2DD,B2DD,GOD,GMD $

126  GKAM     USETD,PHIA,MI,LAMA,DIT,M2DD,B2DD,K2DD,CASEXX/MHH,BHH,KHH,PHIDH/
              V,N,NOUE/C,Y,LMODES=0/C,Y,LFREQ=0.0/C,Y,HFREQ=0.0/V,N,  NOM2PP/
              V,N,NOB2PP/V,N,NOK2PP/V,N,NONCUP/V,N,FMODE $

127  SAVE     NONCUP,FMODE $

128  CHKPNT   MHH,BHH,KHH,PHIDH $

129  CEAD     KHH,BHH,MHH,EED,CASEXX/PHIH,CLAMA,OCEIGS,/V,N,EIGVS $

130  SAVE     EIGVS $

131  CHKPNT   PHIH,CLAMA,OCEIGS $

132  OFP      OCEIGS,CLAMA,,,,,//V,N,CARDNO $

133  SAVE     CARDNO $

134  COND     LBL17,EIGVS $

135  VDR      CASEXX,EQDYN,USETD,PHIH,CLAMA,,,/OPHIH,/C,N,CEIGEN/C,N,MODAL/V,
              N,NOSORT2/V,N,NOH/V,N,NOP/V,N,FMODE $

136  SAVE     NOH,NOP $

137  COND     LBL16,NOH $

138  OFP      OPHIH,,,,,,//V,N,CARDNO $

139  SAVE     CARDNO $


140  LABEL    LBL16 $

141  COND     LBL17,NOP $

142  DDR1     PHIH,PHIDH/CPHID $

143  CHKPNT   CPHID $

144  EQUIV    CPHID,CPHIP/NOA $

145  COND     LBLNOA,NOA $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 10

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


146 SDR1    USETD,,CPHID,,,GOD,GMD,,KFS,,/CPHIP,,QPC/C,N,1 /C,N,DYNAMICS
147 LABEL   LBLNDA $
148 CHKPNT  CPHIP,QPC $
149 SDR2    CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,,CLAMA,QPC,CPHIP,EST,,/    ,
            OQPC1,OCPHIP,OESC1,OEFC1, /C,N,CEIGEN $
150 OFP     OCPHIP,OQPC1,OEFC1,OESC1,,,//V,N,CARDNO $
151 SAVE    CARDNO $
152 LABEL   LBL17 $
153 COND    FINIS,REPEATE $
154 REPT    LBL13,100 $                                  Bottom of DMAP Loop
155 JUMP    ERROR3 $
156 JUMP    FINIS $
157 LABEL   ERROR3 $
158 PRTPARM //C,N,-3/C,N,MDLCEAD $
159 LABEL   ERROR2 $
160 PRTPARM //C,N,-2/C,N,MDLCEAD $
161 LABEL   ERROR1 $
162 PRTPARM //C,N,-1/C,N,MDLCEAD $
163 LABEL   ERROR4 $
164 PRTPARM //C,N,-4/C,N,MDLCEAD $
165 LABEL   FINIS $


166 END     $
```

3.11.2 Description of DMAP Operations for Modal Complex Eigenvalue Analysis

3. GP1 generates coordinate system transformation matrices, table of grid point locations, and tables to relate internal to external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot output is requested.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plots are requested.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Grid Point Temperature Table.

24. TA1 generates element tables for use in matrix assembly and stress recovery.

26. Go to DMAP No. 161 and print error message if there are no structural elements.

31. EMG generates structural element stiffness and mass matrix tables and dictionaries for later assembly.

34. Go to DMAP No. 37 if no stiffness matrix is to be assembled.

35. EMA assembles stiffness matrix $[K^{x}_{gg}]$ and Grid Point Singularity Table.

38. Go to DMAP No. 161 if no mass matrix is to be assembled.

39. EMA assembles mass matrix $[M_{gg}]$.

41. Go to DMAP No. 44 if no weight and balance is requested.

42. GPWG generates weight and balance information.

43. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

45. Equivalence $[K^{x}_{gg}]$ to $[K_{gg}]$ if no general elements.

47. Go to DMAP No. 50 if no general elements.

48. SMA3 adds general elements to stiffness matrix $[K^{x}_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

52. GP4 generates flags defining members of various displacement sets (USET) and forms multi-point constraint equations $[R_g]\{u_g\} = 0$.

57. Go to DMAP No. 62 if general elements present.

58. GPSP determines if possible grid point singularities remain.

60. Go to DMAP No. 62 if no Grid Point Singularity Table.

61. ØFP formats table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

63. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

65. Go to DMAP No. 70 if no multipoint constraints.

66. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

68. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \text{ and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m].$$

71. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

73. Go to DMAP No. 76 if no single-point constraints.

74. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right].$$

77. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

78. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

80. Go to DMAP No. 85 if no omitted coordinates.

81. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

83. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o]$$

86. Go to DMAP No. 95 if no free-body supports.

87. RBMG1 partitions out free-body supports.

89. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

91. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||}$$

93. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

96. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers (GPLD), including extra points introduced for dynamic analysis (SILD), and prepares Transfer Function Pool (TFPØØL), and Eigenvalue Extraction Data (EED).

98. Go to DMAP No. 157 and print error message if no Eigenvalue Extraction Data.

99. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

102. READ extracts real eigenvalues from the equation

$$[K_{aa} - \lambda M_{aa}]\{u_a\} = 0 ,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized and computes rigid body eigenvectors

$$[\phi_{ao}] = \begin{bmatrix} D_m\ \phi_{ro} \\ \hline \phi_{ro} \end{bmatrix} ,$$

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass.

106. ØFP formats the summary of eigenvalue extraction information (ØEIGS) prepared by READ and places it on the system output file for printing.

108. Go to DMAP No. 163 and print error message if no eigenvalues found.

109. ØFP formats the eigenvalues (LAMA) prepared by READ and places them on the system output file for printing.

113. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

114. Beginning of loop for additional sets of direct input matrices.

116. CASE extracts user requests from CASECC for current loop.

119. MTRXIN selects the direct input matrices for the current loop, $[K^2_{pp}]$, $[M^2_{pp}]$ and $[B^2_{pp}]$.

122. Equivalence $[M^2_{pp}]$ to $[M^2_{dd}]$, $[B^2_{pp}]$ to $[B^2_{dd}]$ and $[K^2_{pp}]$ to $[K^2_{dd}]$ if no constraints applied.

124. GKAD applies constraints to direct input matrices $[K^2_{pp}]$, $[M^2_{pp}]$ and $[B^2_{pp}]$, forming $[K^2_{dd}]$, $[M^2_{dd}]$ and $[B^2_{dd}]$.

126. GKAM assembles stiffness, mass and damping matrices in modal coordinates for use in Complex Eigenvalue Analysis.

$$[K_{hh}] = [k] + [\phi^T_{dh}][K^2_{dd}][\phi_{dh}] ,$$

$$[M_{hh}] = [m] + [\phi^T_{dh}][M^2_{dd}][\phi_{dh}],$$

$$[B_{hh}] = [b] + [\phi^T_{dh}][B^2_{dd}][\phi_{dh}],$$

where m_i = modal masses

$b_i = m_i \, 2\pi \, f_i \, g(f_i)$

$k_i = m_i \, 4\pi^2 \, f_i^2$

and direct input matrices may be complex.

129. CEAD extracts complex eigenvalues from the equation

$$[M_{hh}p^2 + B_{hh}p + K_{hh}]\{u_h\} = 0$$

and normalizes eigenvectors according to one of the following user requests:
(1) Unit magnitude of selected coordinate
(2) Unit magnitude of largest component.

132. ØFP formats the summary of complex eigenvalues (CLAMA) and summary of eigenvalue extraction information (ØCEIGS) prepared by CEAD and places them on the system output file for printing.

134. Go to DMAP No. 152 if no complex eigenvalues found.

135. VDR prepares eigenvectors (ØPHIH) for output, using only the extra points introduced for dynamic analysis and modal coordinates.

137. Go to DMAP No. 140 if no output request for the extra points introduced for dynamic analysis or modal coordinates.

138. ØFP formats tables of eigenvectors for extra points introduced for dynamic analysis and modal coordinates prepared by VDR and places them on the system output file for printing.

141. Go to DMAP No. 152 if no output request involving dependent degrees of freedom or forces and stresses.

142. DDR1 transforms the complex eigenvectors from modal to physical coordinates

$$[\phi_d] = [\phi_{dh}][\phi_h].$$

144. Equivalence $[\phi_d]$ to $[\phi_p]$ if no constraints applied.

145. Go to DMAP No. 147 if no constraints applied.

146. SDR1 recovers dependent components of eigenvectors

$$\{\phi_o\} = [G_o^d]\{\phi_d\} \quad , \qquad \begin{Bmatrix} \phi_d \\ \hline\hline \phi_o \end{Bmatrix} = \{\phi_f + \phi_e\} \quad ,$$

$$\begin{Bmatrix} \phi_f + \phi_e \\ \hline\hline \phi_s \end{Bmatrix} = \{\phi_n + \phi_e\} \quad , \qquad \{\phi_m\} = [G_m^d]\{\phi_n + \phi_e\} \quad ,$$

$$\begin{Bmatrix} \phi_n + \phi_e \\ \hline\hline \phi_m \end{Bmatrix} = \{\phi_p\}$$

and recovers single-point forces of constraint $\{q_s\} = [K_{fs}^T]\{\phi_f\}$.

149. SDR2 calculates element forces (ØEFC1) and stresses (ØESC1) and prepares eigenvectors (ØCPHIP) and single-point forces of constraint (ØQPC1) for output.

150. ØFP formats tables prepared by SDR2 and places them on system output file for printing.

153. Go to DMAP No. 165 and make normal exit if no additional sets of direct input matrices need to be processed.

154. Go to DMAP No. 114 if additional sets of direct input matrices need to be processed.

155. Go to DMAP No. 157 and print error message if more than 100 loops.

156. Go to DMAP No. 165 and make normal exit.

158. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

160. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

162. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

164. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

3.11.3 Automatic Output for Modal Complex Eigenvalue Analysis

The Eigenvalue Summary Table and the Eigenvalue Analysis Summary, as described under Normal Mode Analysis, are automatically printed. All real eigenvalues extracted are included even though not all are used in the modal formulation.

The Complex Eigenvalue Summary Table and the Complex Eigenvalue Analysis Summary, as described under Direct Complex Eigenvalue Analysis, are automatically printed for each set of direct input matrices.

3.11.4 Case Control Deck and Parameters for Modal Complex Eigenvalue Analysis

The following items related to subcase definition and data selection must be considered in addition to the list presented with Direct Complex Eigenvalue Analysis:

1. METHØD must appear above the subcase level to select an EIGR card that exists in the Bulk Data Deck.
2. All of the eigenvectors used in the modal formulation must be determined in a single execution.
3. An SPC set must be selected above the subcase level unless the model is a free body or all constraints are specified on GRID cards, Scalar Connection cards or with General Elements.
4. SDAMPING must be used to select a TABDMP1 table if structural damping is desired.

Output that may be requested is the same as that described under Direct Complex Eigenvalue Analysis. Output for SØLUTIØN points will have the modal coordinates identified by the mode number determined in Real Eigenvalue Analysis.

The eigenvectors used in the modal formulation may be obtained for the SØLUTIØN points by using the ALTER feature to print the matrix of eigenvectors following the execution of READ. The eigenvectors for all points in the model may be obtained by running the problem initially on the Normal Mode Analysis rigid format or by making a modified restart using the Normal Mode Analysis rigid format.

The following parameters are used in Modal Complex Eigenvalue Analysis:

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

4. LFREQ and HFREQ - required unless LMØDES is used. The real values of these parameters give the frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation.

5. LMØDES - required unless LFREQ and HFREQ are used. The integer value of this parameter is the number of lowest modes to be used in the modal formulation.

3.11.5 Optional Diagnostic Output for FEER

Special detailed information resulting from requesting DIAG 16 in the Executive Control Deck is the same as described under Normal Modes analysis (see Section 3.4.6).

3.11.6 The APPEND Feature

The APPEND feature can be used for real eigenvalue extraction in Modal Complex Eigenvalue Analysis. See Section 3.4.7 for details.

3.12 MODAL FREQUENCY AND RANDOM RESPONSE

3.12.1 DMAP Sequence for Modal Frequency and Random Response

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 11

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN    NO.11 MODAL FREQUENCY RESPONSE ANALYSIS - SERIES P $

    2  FILE     GOO=SAVE/ GMD=SAVE/ LAMA=APPEND/ PHIA=APPEND $

    3  GP1      GEOM1,GEOM2,,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT $

    4  SAVE     LUSET $

    5  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

    6  GP2      GEOM2,EQEXIN/ECT $

    7  CHKPNT   ECT $

    8  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

    9  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

   10  COND     P1,NOPCDB $

   11  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/  V,N,
                JUMPPLOT=-1 $

   12  SAVE     NSIL,JUMPPLOT $

   13  PRTMSG   PLTSETX// $

   14  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

   15  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

   16  COND     P1,JUMPPLOT $

   17  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

   18  SAVE     JUMPPLOT,PLTFLG,PFILE $


   19  PRTMSG   PLOTX1// $

   20  LABEL    P1 $

   21  CHKPNT   PLTPAR,GPSETS,ELSETS $

   22  GP3      GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $

   23  CHKPNT   GPTT $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 11

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


24  (TA1)     ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,,/V,N,LUSET/V,N,
              NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

25  SAVE      NOGENL,NOSIMP,GENEL $

26  COND      ERROR1,NOSIMP $

27  PURGE     OGPST/GENEL $

28  CHKPNT    EST,GPECT,GEI,OGPST $

29  PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

30  PARAM     //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

31  (EMG)     EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
              N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
              CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
              CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

32  SAVE      NOKGGX,NOMGG $

33  CHKPNT    KELM,KDICT,MELM,MDICT $

34  COND      JMPKGGX,NOKGGX $

35  (EMA)     GPECT,KDICT,KELM/KGGX,GPST $

36  CHKPNT    KGGX,GPST $

37  LABEL     JMPKGGX $

38  COND      ERROR1,NOMGG $

39  (EMA)     GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

40  CHKPNT    MGG $

41  COND      LGPWG,GRDPNT $


42  (GPWG)    BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $

43  OFP       OGPWG,,,,,// $

44  LABEL     LGPWG $

45  EQUIV     KGGX,KGG/NOGENL $

46  CHKPNT    KGG $

47  COND      LBL11,NOGENL $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 11

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


48  (SMA3)    GET,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
49  CHKPNT    KGG $
50  LABEL     LBL11 $
51  PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
52  (GP4)     CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/PG,,USET,ASET/  V,N,LUSET/
              V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
              N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
53  SAVE      MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2,NSKIP,REPEAT,NOL,NOA $
54  PARAM     //C,N,AND/V,N,NOSP/V,N,REACT/V,N,SINGLE $
55  PURGE     GM,GMD/MPCF1/GO,GOD/OMIT/KFS,PSF/SINGLE/OPC/NOSP/KLR,KRR,MLR,
              MRR,DM,MP/REACT/MOD/MODACC $
56  CHKPNT    KRR,KLR,DM,MLR,MRR,MP,GM,PG,GO,KFS,PSF,OPC,USET,GOD,GMD,ASET $
57  COND      LBL4,GENEL $
58  (GPSP)    GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
59  SAVE      NOGPST $
60  COND      LBL4,NOGPST $
61  OFP       OGPST,,,,,// $
62  LABEL     LBL4 $
63  EQUIV     KGG,KNN/MPCF1/MGG,MNN/MPCF1 $
64  CHKPNT    KNN,MNN $
65  COND      LBL2,MPCF1 $
66  (MCF1)    USET,PG/GM $

67  CHKPNT    GM $
68  (MCF2)    USET,GM,KGG,MGG,,/KNN,MNN,, $
69  CHKPNT    KNN,MNN $
70  LABEL     LBL2 $
71  EQUIV     KNN,KFF/SINGLE/MNN,MFF/SINGLE $
72  CHKPNT    KFF,MFF $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 11

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


73   COND      LBL3,SINGLE $
74   SCE1      USET,KNN,MNN,,/KFF,KFS,,MFF,, $
75   CHKPNT    KFS,KFF,MFF $
76   LABEL     LBL3 $
77   EQUIV     KFF,KAA/OMIT $
78   EQUIV     MFF,MAA/OMIT $
79   CHKPNT    KAA,MAA $
80   COND      LBL5,OMIT $
81   SMP1      USET,KFF,,,,/GO,KAA,KOO,LOO,,,,, $
82   CHKPNT    GO,KAA $
83   SMP2      USET,GO,MFF/MAA $
84   CHKPNT    MAA $
85   LABEL     LBL5 $
86   EQUIV     KAA,KLL/REACT $
87   CHKPNT    KLL $
88   COND      LBL6,REACT $
89   SMRG1     USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $
90   CHKPNT    KLL,KLR,KRR,MLL,MLR,MRR $
91   JUMP      LBLR $
92   LABEL     LBL6 $


93   COND      LBL7,MODACC $
94   LABEL     LBLR $
95   SMRG2     KLL/LLL $
96   CHKPNT    LLL $
97   COND      LBL7,REACT $
98   SMRG2     LLL,KLR,KRR/DM $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 11

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


 99  CHKPNT   DM $
100  RBMG4    DM,MLL,MLR,MRR/MR $
101  CHKPNT   MR $
102  LABEL    LBL7 $
103  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TEPOOL,DLT,PSDL,ERL,,,
              EED,EQDYN/V,N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/
              V,N,NOERL/V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $
104  SAVE     LUSETD,NOUE,NODLT,NOERL,NOEED,NOPSDL $
105  COND     ERROR2,NOEED $
106  PURGE    UEVE/NOUE $
107  EQUIV    GO,GOD/NOUE/GM,GMD/NOUE $
108  CHKPNT   USETD,EQDYN,TEPOOL,DLT,ERL,EED,GOD,GMD,UEVE,SILD,PSDL,GPLD $
109  PARAM    //C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 $
110  READ     KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N,
              NEIGV $
111  SAVE     NEIGV $
112  CHKPNT   LAMA,PHIA,MI,OEIGS $
113  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
114  OFP      OEIGS,,,,,//V,N,CARDNO $
115  SAVE     CARDNO $
116  COND     ERROR4,NEIGV $
117  OFP      LAMA,,,,,//V,N,CARDNO $

118  SAVE     CARDNO $
119  PARAM    //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $
120  PARAM    //C,N,MPY/V,N,REPEATE/C,N,1/C,N,-1 $
121  JUMP     LBL13 $
                                                  Top of DMAP Loop
122  LABEL    LBL13 $
123  PURGE    OUHVC1,OUHVC2,XYPLTEA,OPPC1,OQPC1,OUPVC1,OESC1,OEEC1,OPPC2,
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 11

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


                OOPC2,OUPVC2,OESC2,OEFC2,XYPLTF,PSDF,AUTO,XYPLTP,K2PP,M2PP,
                B2PP,K2DD,M2DD,B2DD,OPPCA,IQP1,IPHIP1,IES1,IEF1,OPPCB,IQP2,
                IPHIP2,IES2,IEF2,ZOPC2,ZUPVC2,ZESC2,ZEFC2,ZOPC1,ZUPVC1,ZESC1,
                ZEFC1/NEVER $

124  (CASE)     CASECC,PSDL/CASEXX/C,N,FREQ/V,N,REPEATF/V,N,NOLOOP $

125  SAVE       REPEATF,NOLOOP $

126  CHKPNT     CASEXX $

127  (MTRXIN)   CASEXX,MATPOOL,EQDYN,,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N,
                NOK2PP/V,N,NOM2PP/V,N,NOB2PP $

128  SAVE       NOK2PP,NOM2PP,NOB2PP $

129  PURGE      K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $

130  PARAM      //C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP $

131  EQUIV      M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDEMA $

132  CHKPNT     K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,MDD $

133  (GKAD)     USETD,GM,GO,,,MAA,,K2PP,M2PP,B2PP/,,MDD,GMD,   GOD,K2DD,M2DD,
                B2DD/C,N,FREQRESP/C,N,DISP/C,N,MODAL/C,N,0.0/ C,N,0.0/C,N,0.0/
                V,N,NOK2PP/V,N,NOM2PP/V,N,NOB2PP/   V,N,MPCF1/V,N,SINGLE/V,N,
                OMIT/V,N,NOUE/C,N,-1/C,N,-1/   C,N,+1/V,Y,MODACC = -1 $

134  CHKPNT     MDD,GMD,GOD,K2DD,M2DD,B2DD $

135  (GKAM)     USETD,PHIA,MI,LAMA,DIT,M2DD,B2DD,K2DD,CASEXX/MHH,BHH,KHH,PHIDH/
                V,N,NOUE/C,Y,LMODES=0/C,Y,LFREQ=0.0/C,Y,HFREQ=0.0/V,N,  NOM2PP/
                V,N,NOB2PP/V,N,NOK2PP/V,N,NONCUP/V,N,EMODE $

136  SAVE       NONCUP,EMODE $

137  CHKPNT     MHH,BHH,KHH,PHIDH $

138  COND       ERROR5,NOFRL $


139  COND       ERROR6,NODLT $

140  (FRRD)     CASEXX,USETD,DLT,FRL,GMD,GOD,KHH,BHH,MHH,PHIDH,DIT/UHVF,PSF,
                PDF,PPF/C,N,DISP/C,N,MODAL/V,N,LUSETD/V,N,MPCF1/V,N,SINGLE/V,N,
                OMIT/V,N,NONCUP/V,N,FROSET $

141  SAVE       FROSET $

142  EQUIV      PPF,PDF/NOSET $

143  CHKPNT     PSF,PPF,UHVF,PDF $
```

```
 RIGID FORMAT DMAP LISTING
 SERIES P

 DISPLACEMENT APPROACH, RIGID FORMAT 11

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


144 (VDR)     CASEXX,EQDYN,USETD,UHVF,PPF,XYCDB,/OUHVC1,/C,N,FREQRESP/C,N,
              MODAL/V,N,NOSORT2/V,N,NOH/V,N,NOP/V,N,FMODE $
145  SAVE     NOH,NOP,NOSORT2 $
146  COND     LBL16,NOH $
147  COND     LBL16A,NOSORT2 $
148  CHKPNT   OUHVC1 $
149 (SDR3)    OUHVC1,,,,,/OUHVC2,,,,, $
150  OFP      OUHVC2,,,,,//V,N,CARDNO $
151  SAVE     CARDNO $
152  CHKPNT   OUHVC2 $
153 (XYTRAN)  XYCDB,OUHVC2,,,,/XYPLTFA/C,N,FREQ/C,N,HSET/V,N,PFILE/V,N,
              CARDNO $
154  SAVE     PFILE,CARDNO $
155 (XYPLOT)  XYPLTFA // $
156  JUMP     LBL16 $
157  LABEL    LBL16A $
158  OFP      OUHVC1,,,,,//V,N,CARDNO $
159  SAVE     CARDNO $
160  LABEL    LBL16 $
161  COND     LBL14,NOP $
162  PARAM    //C,N,NOT/V,N,NOMOD/V,Y,MODACC $

163  COND     LBDDRM,MODACC $
164 (DDR1)    UHVF,PHIDH/UDV1F $
165  CHKPNT   UDV1F $
166 (DDR2)    USETD,UDV1F,PDF,K2DD,B2DD,MDD,PPF,LLL,DM/UDV2F,UEVF,PAF/   C,N,
              FREQRESP/V,N,NOUE/V,N,REACT/V,N,FROSET $
167  CHKPNT   UDV2F,UEVF,PAF $
168  EQUIV    UDV2F,UDV1F/NOMOD $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 11

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


169  CHKPNT   UDV1F $
170  EQUIV    UDV1F,UPVC/NOA $
171  COND     LBLNOA,NOA $
172  SDR1     USETD,,UDV1F,,,GOD,GMD,PSF,KFS,,/UPVC,,OPC/C,N,1/C,N,DYNAMICS $
173  LABEL    LBLNOA $
174  CHKPNT   UPVC,OPC $
175  SDR2     CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,BGPDT,PPF,OPC,UPVC,EST,
              XYCDB,PPF/OPPC1,OQPC1,OUPVC1,OESC1,OEFC1,PUGV/C,N,FREQ/ V,N,
              NOSORT2 $
176  SAVE     NOSORT2 $
177  COND     LBL1P,NOSORT2 $
178  SDR3     OPPC1,OQPC1,OUPVC1,OESC1,OEFC1,/OPPC2,OQPC2,OUPVC2,OESC2,
              OEFC2, $
179  JUMP     P2A $
180  LABEL    LBDDRM $
181  SDR1     USETD,,PHIPH,,,,GOD,GMD,,KFS,,/PHIPH,,QPH/C,N,1/C,N,DYNAMICS $
182  SDR2     CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,,LAMA,QPH,PHIPH,EST,XYCDB,/
              ,IOP1,IPHIP1,IFS1,IEF1,/C,N,MMREIG/V,N,NOSORT2 $
183  SAVE     NOSORT2 $
184  SDR2     CASEXX,,,,EQDYN,SILD,,,,PPF,,,,,XYCDB,PPF/OPPCA,,,,,,/C,N,FREQ $
185  EQUIV    OPPCA,OPPC1/MODACC $
186  COND     LBLSORT,NOSORT2 $

187  SDR3     IOP1,IPHIP1,IFS1,IEF1,OPPCA,/IOP2,IPHIP2,IFS2,IEF2,OPPCB, $
188  EQUIV    OPPCB,OPPC2/MODACC $
189  DDRMM    CASEXX,UHVF,PPF,IPHIP2,IOP2,IFS2,IEF2,XYCDB,FRL,MPT,DIT/
              ZUPVC2,ZOPC2,ZESC2,ZEFC2, $
190  EQUIV    ZUPVC2,OUPVC2/MODACC/ZOPC2,OQPC2/MODACC/ZESC2,OESC2/MODACC/
              ZEFC2,OEFC2/MODACC $
191  JUMP     P2A $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 11

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


192  LABEL     LBLSORT $
193  DDRMM     CASEXX,UHVF,PPF,IPHIP1,IOP1,IES1,IEF1,,EST,MPT,DIT/   ZUPVC1,
               ZOPC1,ZESC1,ZEFC1, $
194  EQUIV     ZUPVC1,OUPVC1/MODACC/ZOPC1,OOPC1/MODACC/ZESC1,OESC1/MODACC/
               ZEFC1,OEFC1/MODACC $
195  JUMP      LBL18 $
196  LABEL     P2A $
197  CHKPNT    OUPVC2,OPPC2,OOPC2,OESC2,OEFC2 $
198  OFP       OPPC2,OOPC2,OUPVC2,OEFC2,OESC2,//V,N,CARDNO $
199  SAVE      CARDNO $
200  XYTRAN    XYCDB,OPPC2,OOPC2,OUPVC2,OESC2,OEFC2/XYPLTF/C,N,FREQ/C,N,PSET/
               V,N,PFILE/V,N,CARDNO $
201  SAVE      PFILE,CARDNO $
202  XYPLOT    XYPLTF// $
203  COND      LBL21,JUMPPLOT $
204  PLOT      PLTPAR,GPSETS,ELSETS,CASEXX,BGPDT,SEQEXIN,SIL,,PUGV,,/  PLOTX2/
               V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
205  SAVE      PFILE $
206  LABEL     LBL21 $
207  COND      LBL14,NOPSDL $
208  RANDOM    XYCDB,DIT,PSDL,OUPVC2,OPPC2,OOPC2,OESC2,OEFC2,CASEXX/FSDF,AUTO/
               V,N,NORD $
209  SAVE      NORD $


210  CHKPNT    PSDF,AUTO $
211  COND      LBL14,NORD $
212  XYTRAN    XYCDB,PSDF,AUTO,,,/XYPLTR/C,N,RAND/C,N,PSET/V,N,PFILE/   V,N,
               CARDNO $
213  SAVE      PFILE,CARDNO $
214  XYPLOT    XYPLTR// $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 11

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


215  JUMP     LBL14 $
216  LABEL    LBL18 $
217  DEP      OUPVC1,OPPC1,OQPC1,OEFC1,OESC1,//V,N,CARDNO $
218  SAVE     CARDNO $
219  LABEL    LBL14 $
220  COND     FINIS,REPEATF $
221  REPT     LBL13,100 $
222  JUMP     ERROR3 $
223  JUMP     FINIS $
224  LABEL    ERROR3 $
225  PRTPARM  //C,N,-3/C,N,MDLERRD $
226  LABEL    ERROR2 $
227  PRTPARM  //C,N,-2/C,N,MDLERRD $
228  LABEL    ERROR1 $
229  PRTPARM  //C,N,-1/C,N,MDLERRD $
230  LABEL    ERROR4 $
231  PRTPARM  //C,N,-4/C,N,MDLERRD $
232  LABEL    ERROR5 $
233  PRTPARM  //C,N,-5/C,N,MDLERRD $
234  LABEL    ERROR6 $

235  PRTPARM  //C,N,-6/C,N,MDLERRD $
236  LABEL    FINIS $
237  END      $
```

Bottom of DMAP Loop

3.12.2 Description of DMAP Operations for Modal Frequency and Random Response

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot output is requested.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plots are requested.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Grid Point Temperature Table.

24. TA1 generates element tables for use in matrix assembly and stress recovery.

26. Go to DMAP No. 228 and print error messages if there are no structural elements .

31. EMG generates structural element stiffness and mass matrix tables and dictionaries for later assembly.

34. Go to DMAP No. 37 if no stiffness matrix is to be assembled.

35. EMA assembles stiffness matrix $[K^{x}_{gg}]$ and Grid Point Singularity Table.

38. Go to DMAP No. 228 if no mass matrix is to be assembled.

39. EMA assembles stiffness matrix $[M_{gg}]$.

41. Go to DMAP No. 44 if no weight and balance is requested.

42. GPWG generates weight and balance information.

43. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

45. Equivalence $[K^{x}_{gg}]$ to $[K_{gg}]$ if no general elements.

47. Go to DMAP No. 50 if no general elements.

48. SMA3 adds general elements to stiffness matrix $[K^{x}_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

52. GP4 generates flags defining members of various displacement sets (USET) and forms multi-point constraint equations $[R_g]\{u_g\} = 0$.

57. Go to DMAP No. 62 if general elements present.

58. GPSP determines if possible grid point singularities remain.

60. Go to DMAP No. 62 if no grid point singularities remain.

61. ØFP formats table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

63. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

65. Go to DMAP No. 70 if no multipoint constraints.

66. MCE1 partitions multipoint constraint equations $[R_g] = [R_m | R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

68. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \text{ and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m].$$

71. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints

73. Go to DMAP No. 76 if no single-point constraints.

74. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right] .$$

77. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

78. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

80. Go to DMAP No. 85 if no omitted coordinates.

81. SMP1 partitions constrained stiffness matrix.

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

83. SMP2 partitions constrained mass matrix.

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [\bar{G}_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o].$$

86. Equivalence $[K_{aa}]$ to $[K_{\ell\ell}]$ if no free-body supports.

88. Go to DMAP No. 92 if no free-body supports.

89. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] \quad \text{and} \quad [M_{aa}] = \left[\begin{array}{c|c} M_{\ell\ell} & M_{\ell r} \\ \hline M_{r\ell} & M_{rr} \end{array}\right] .$$

91. Go to DMAP No. 94 because supports are present and mode acceleration is used.

93. Go to DMAP No. 102 if no request for mode acceleration data recovery.

95. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

97. Go to DMAP No. 102 if no free-body supports.

98. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||}$$

100. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

103. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers (GPLD), including extra points introduced for dynamic analysis (SILD), and prepares Transfer Function Pool (TFPØØL), Dynamic Loads Table (DLT), Power Spectral Density List (PSDL), Frequency Response List (FRL), and Eigenvalue Extraction Data (EED).

105. Go to DMAP No. 226 and print error message if no Eigenvalue Extraction Data.

107. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

110. READ extracts real eigenvalues from the equation

$$[K_{aa} - \lambda M_{aa}]\{u_a\} = 0 ,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized and computes rigid body eigenvectors

$$[\phi_{ao}] = \left[\begin{array}{c|c} D_m & \phi_{ro} \\ \hline & \\ \hline \phi_{ro} & \end{array}\right] ,$$

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass.

114. ØFP formats the summary of eigenvalue extraction information (ØEIGS) prepared by READ and places it on the system output file for printing.

116. Go to DMAP No. 230 and print error message if no eigenvalues found.

117. ØFP formats the eigenvalues (LAMA) prepared by READ and places them on the system output file for printing.

121. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

122. Beginning of loop for additional sets of direct input matrices.

124. CASE extracts user requests from CASECC for current loop.

127. MTRXIN selects the direct input matrices for the current loop, $[K^2_{pp}]$, $[M^2_{pp}]$ and $[B^2_{pp}]$.

131. Equivalence $[M^2_{pp}]$ to $[M^2_{dd}]$, $[B^2_{pp}]$ to $[B^2_{dd}]$ and $[K^2_{pp}]$ to $[K^2_{dd}]$ if no constraints applied and $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points introduced for Dynamic analysis.

133. GKAD applies constraints to direct input matrices $[K^2_{pp}]$, $[M^2_{pp}]$ and $[B^2_{pp}]$, forming $[K^2_{dd}]$, $[M^2_{dd}]$ and $[B^2_{dd}]$.

135. GKAM assembles stiffness, mass, and damping matrices in modal coordinates for use in Frequency Response.

$$[K_{hh}] = [k] + [\phi_{dh}^T][K^2_{dd}][\phi_{dh}] ,$$

$$[M_{hh}] = [m] + [\phi_{dh}^T][M^2_{dd}][\phi_{dh}],$$

$$[B_{hh}] = [b] + [\phi_{dh}^T][B^2_{dd}][\phi_{dh}],$$

where

m_i = modal masses

$b_i = m_i \, 2\pi \, f_i \, g(f_i)$

$k_i = m_i \, 4\pi^2 f_i^2$

and direct input matrices may be complex.

138. Go to DMAP No. 232 and print error message if no Frequency Response List.

139. Go to DMAP No. 234 and print error message if no Dynamic Loads Table.

140. FRRD forms the dynamic load vectors $\{P_h\}$ and solves for the displacements using the following equation

$$[-M_{hh}\omega^2 + iB_{hh}\omega + K_{hh}]\{u_h\} = \{P_h\}.$$

142. Equivalence $\{P_p\}$ to $\{P_d\}$ if no constraints applied.

144. VDR prepares displacements (ØUHVC1), sorted by frequency, for output using only the extra points introduced for dynamic analysis and modal coordinates (solution points).

146. Go to DMAP No. 160 if no output request for solution points.

147. Go to DMAP No. 157 if no output request for solution points sorted by extra point or mode number.

149. SDR3 sorts the solution point displacements by extra point or mode num-er.

150. ØFP formats the requested solution point displacements prepared by SDR3 and places them on the system output file for printing.

153. XYTRAN prepares the input for X-Y plotting of the solution point displacements vs. frequency.

155. XYPLØT prepares requested X-Y plots of the solution point displacements vs. frequency.

156. Go to DMAP No. 160 because the solution point displacements are sorted by extra point or mode number.

158. ØFP formats the requested solution point displacements prepared by VDR and places them on the system output file for printing.

161. Go to DMAP No. 215 if no output request involving dependent degrees of freedom or forces and stresses.

163. Go to DMAP No. 180 if mode acceleration technique not requested.

164. DDR1 transforms the solution vector of displacements from modal to physical coordinates

$$\{u_d\} = [\phi_{dh}]\{u_h\}$$

166. DDR2 calculates an improved displacement vector using the mode acceleration technique, if requested.

170. Equivalence $\{u_d\}$ to $\{u_p\}$ if no constraints applied.

171. Go to DMAP No. 173 if no constraints applied.

172. SDR1 recovers dependent components of displacements

$$\{u_o\} = [G_o^d]\{u_d\} \quad , \qquad \begin{Bmatrix} u_d \\ \hline u_o \end{Bmatrix} = \{u_f + u_e\} \quad ,$$

$$\begin{Bmatrix} u_f + u_e \\ \hline u_s \end{Bmatrix} = \{u_n + u_e\} \quad , \qquad \{u_m\} = [G_m^d]\{u_f + u_e\} \quad ,$$

$$\begin{Bmatrix} u_n + u_e \\ \hline u_m \end{Bmatrix} = \{u_p\}$$

and recovers single-point forces of constraint $\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\}$.

175. SDR2 calculates element forces (ØEFC1) and stresses (ØESC1) and prepares load vectors (ØPPC1), displacement vectors (ØUPVC1) and single-point forces of constraint (ØQPC1) for output, sorted by frequency.

177. Go to DMAP No. 216 if no output requests sorted by point number of element number.

178. SDR3 prepares requested output sorted by point number or element number.

179. Go to DMAP No. 196 because no mode acceleration requested.

181. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o^d]\{\phi_n\} \quad , \qquad \begin{Bmatrix} \phi_n \\ \hline \phi_o \end{Bmatrix} = \{\phi_f + u_e\}$$

$$\begin{Bmatrix} \phi_f + u_e \\ \hline \phi_s \end{Bmatrix} = \{\phi_n + u_e\} \qquad \{\phi_m\} = [G_m^d]\{\phi_n + u_e\}$$

$$\begin{Bmatrix} \phi_n + u_e \\ \hline \phi_m \end{Bmatrix} = \{\phi_g + u_e\} = \{\phi_p\} \quad .$$

and recovers single-point forces of constraint

$$\{q_s\} = [K_{fs}]^T\{\phi_f\} \quad .$$

182. SDR2 calculates element forces (IEF1) and stresses (IES1) and prepares eigenvectors (IPHIP1) and single-point forces of constraint (IQP1) for output sorted by frequency.

184. SDR2 prepares load vectors for output (ØPPCA) sorted by frequency.

185. Equivalence ØPPCA to ØPPC1 if mode acceleration requested.

186. Go to DMAP No. 192 if no output requested by point number or element number sort.

187. SDR3 prepares requested output sorted by point number or element number.

188. Equivalence ØPPCB to ØPPC2 if mode acceleration requested.

189. DDRMM prepares a subset of the element forces (ZEFC2) and stresses (ZESC2), and displacement vectors (ZUPVC2) and single-point forces of constraint (ZQPC2) solutions for output by point number or element number sort.

190. Equivalence ZUPVC2 to ØUPVC2, ZQPC2 to ØQPC2, ZESC2 to ØESC2, and ZEFC2 to ØEFC2 if mode acceleration requested.

191. Go to DMAP No. 196 because requested output is sorted by point number or element number.

193. DDRMM prepares a subset of the element forces (ZEFC1) and stresses (ZESC1) and displacement vectors (ZUPVC1) and single-point forces of constraint (ZQPC1) solutions for output.

194. Equivalence ZUPVC1 to ØUPVC1, ZQPC1 to ØQPC1, ZESC1 to ØESC1, and ZEFC1 to ØEFC1 if mode accelerations are requested.

195. Go to DMAP No. because requested output is not sorted by point number or element number.

198. ØFP formats the requested output prepared by SDR3 (no mode acceleration) or DDRMM (with mode acceleration) and places it on the system output file for printing.

200. XYTRAN prepares the input for requested X-Y plots.

202. XYPLØT prepares requested X-Y plots of displacements, forces, stresses, loads or single-point forces of constraint vs. frequency.

203. Go to DMAP No. 206 if no deformed structure plots are requested.

204. PLØT generates all requested deformed structure and contour plots.

207. Go to DMAP No. 219 if no power spectral density functions or autocorrelation functions requested.

208. RANDØM calculates power spectral density functions (PSDF) and autocorrelation functions (AUTØ) using the previously calculated frequency response.

211. Go to DMAP No. 215 if no X-Y plots of RANDØM calculations requested.

212. XYTRAN prepares the input for requested X-Y plots of the RANDØM output.

214. XYPLØT prepares requested X-Y plots of autocorrelation functions and power spectral density functions.

216. Go to DMAP No. 215 because there are no frequency response output requests sorted by frequency.

217. ØFP formats the frequency response output requests prepared by SDR2 and places them on the system output file for printing.

219. Go to DMAP No. 236 and make normal exit if no additional sets of direct input matrices need to be processed.

221. Go to DMAP No. 122 if additional sets of direct input matrices need to be processed.

222. Go to DMAP No. 224 and print error message if more than 100 loops.

223. Go to DMAP No. 236 and make normal exit.

225. MØDAL FREQUENCY AND RANDØM RESPONSE ERRØR MESSAGE NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

227. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

229. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

231. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

233. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 5 - FREQUENCY RESPØNSE LIST REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

235. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 6 - DYNAMIC LØADS TABLE REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

3.12.3 Automatic Output for Modal Frequency and Random Response

The Eigenvalue Summary Table and the Eigenvalue Analysis Summary, as described under Normal Mode Analysis, are automatically printed. All real eigenvalues extracted are included even though not all are used in the modal formulation.

3.12.4 Case Control Deck and Parameters for Modal Frequency and Random Response

The following items related to subcase definition and data selection must be considered in addition to the list presented with Direct Frequency and Random Response:

1. METHØD must appear above the subcase level to select an EIGR card that exists in the Bulk Data Deck.
2. All of the eigenvectors used in the modal formulation must be determined in a single execution.
3. An SPC set must be selected above the subcase level unless the model is a free body or all constraints are specified on GRID cards, Scalar Connection cards or with General Elements.
4. SDAMPING must be used to select a TABDMP1 table if structural damping is desired.

Printed output and X-Y plots that may be requested is the same as that described under Direct Frequency and Random Response. Output for SØLUTIØN points will have the modal coordinates identified by the mode number determined in Real Eigenvalue Analysis.

The following plotter output is also available in Modal Frequency and Random Response:

1. Deformed shapes of the structural model for selected frequency intervals.
2. Contour plots of stress and displacement for selected frequency intervals.

The eigenvectors used in the modal formulation may be obtained for the SØLUTIØN points by using the ALTER feature to print the matrix of eigenvectors following the execution of READ. The eigenvectors for all points in the model may be obtained by running the problem initially on the Normal Mode Analysis rigid format or by making a modified restart using the Normal Mode Analysis rigid format.

The following parameters are used in Modal Frequency and Random Response:

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CRQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

4. LFREQ and HFREQ - required unless LMØDES is used. The real values of these parameters give the frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation.

5. LMØDES - required unless LFREQ and HFREQ are used. The integer value of this parameter is the number of lowest modes to be used in the modal formulation.

6. MØDACC - optional - A positive integer value of this parameter causes the Dynamic Data Recovery module to use the mode acceleration method. Not recommended for use in hydroelastic problems.

3.12.5 Optional Diagnostic Output for FEER

Special detailed information resulting from requesting DIAG 16 in the Executive Control Deck is the same as described under Normal Modes analysis (see Section 3.4.6).

3.12.6 The APPEND Feature

The APPEND feature can be used for real eigenvalue extraction in Modal Frequency and Random Response. See Section 3.4.7 for details.

3.13 MODAL TRANSIENT RESPONSE

3.13.1 DMAP Sequence for Modal Transient Response

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 12

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN    NO.12 MODAL TRANSIENT RESPONSE ANALYSIS - SERIES P $

    2  FILE     LAMA=APPEND/PHIA=APPEND/UHVT=APPEND/TOL=APPEND $

    3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT $

    4  SAVE     LUSET $

    5  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

    6  GP2      GEOM2,EQEXIN/ECT $

    7  CHKPNT   ECT $

    8  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

    9  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

   10  COND     P1,NOPCDB $

   11  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
                JUMPPLOT=-1 $

   12  SAVE     NSIL,JUMPPLOT $

   13  PRTMSG   PLTSETX// $

   14  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

   15  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

   16  COND     P1,JUMPPLOT $

   17  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

   18  SAVE     JUMPPLOT,PLTFLG,PFILE $


   19  PRTMSG   PLOTX1// $

   20  LABEL    P1 $

   21  CHKPNT   PLTPAR,GPSETS,ELSETS $

   22  GP3      GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $

   23  CHKPNT   SLT,GPTT $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 12

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


24  TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,,,/V,N,LUSET/V,N,
              NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

25  SAVE      NOGENL,NOSIMP,GENEL $

26  COND      ERROR1,NOSIMP $

27  PURGE     OGPST/GENEL $

28  CHKPNT    EST,GPECT,GEI,OGPST $

29  PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

30  PARAM     //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

31  EMG       EST,CSTM,MPT,DIT,GEOM2,,/KELM,KDICT,MELM,MDICT,,,/V,N,NOKGGX/ V,
              N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
              CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
              CPQDPLT/C,Y,CPTPPLT/C,Y,CPTRBSC $

32  SAVE      NOKGGX,NOMGG $

33  CHKPNT    KELM,KDICT,MELM,MDICT $

34  COND      JMPKGGX,NOKGGX $

35  EMA       GPECT,KDICT,KELM/KGGX,GPST $

36  CHKPNT    KGGX,GPST $

37  LABEL     JMPKGGX $

38  COND      ERROR1,NOMGG $

39  EMA       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

40  CHKPNT    MGG $

41  COND      LGPWG,GRDPNT $


42  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $

43  OFP       OGPWG,,,,,// $

44  LABEL     LGPWG $

45  EQUIV     KGGX,KGG/NOGENL $

46  CHKPNT    KGG $

47  COND      LBL11,NOGENL $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 12

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


48  SMA3    GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
49  CHKPNT  KGG $
50  LABEL   LBL11 $
51  PARAM   //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
52  GP4     CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,LUSET/
            V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
            N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
53  SAVE    MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2,NSKIP,REPEAT,NOL,NOA $
54  PARAM   //C,N,AND/V,N,NOSR/V,N,REACT/V,N,SINGLE $
55  PURGE   GM,GMD/MPCF1/GO,GOD/OMIT/KFS,PST/SINGLE/QP/NOSR/KLR,KRR,MLR,MR,
            MRR,DM/REACT $
56  CHKPNT  KRR,KLR,DM,MLR,MRR,MR,GM,RG,GO,KFS,PST,QP,USET,GOD,GMD,ASET $
57  COND    LBL4,GENEL $
58  GPSP    GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
59  SAVE    NOGPST $
60  COND    LBL4,NOGPST $
61  OFP     OGPST,,,,,// $
62  LABEL   LBL4 $
63  EQUIV   KGG,KNN/MPCF1/MGG,MNN/MPCF1 $
64  CHKPNT  KNN,MNN $
65  COND    LBL2,MPCF1 $
66  MCE1    USET,RG/GM $

67  CHKPNT  GM $
68  MCE2    USET,GM,KGG,MGG,,/KNN,MNN,, $
69  CHKPNT  KNN,MNN $
70  LABEL   LBL2 $
71  EQUIV   KNN,KFF/SINGLE/MNN,MFF/SINGLE $
72  CHKPNT  KFF,MFF $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 12

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


73  COND      LBL3,SINGLE $
74  SCE1      USET,KNN,MNN,,,/KFF,KFS,,MFF,, $
75  CHKPNT    KFS,KFF,MFF $
76  LABEL     LBL3 $
77  EQUIV     KFF,KAA/OMIT $
78  EQUIV     MFF,MAA/OMIT $
79  CHKPNT    KAA,MAA $
80  COND      LBL5,OMIT $
81  SMP1      USET,KFF,,,,/GO,KAA,KOO,LOO,,,,, $
82  CHKPNT    GO,KAA $
83  SMP2      USET,GO,MFF/MAA $
84  CHKPNT    MAA $
85  LABEL     LBL5 $
86  EQUIV     KAA,KLL/REACT $
87  CHKPNT    KLL $
88  COND      LBL6,REACT $
89  RBMG1     USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $
90  CHKPNT    KLL,KLR,KRR,MLL,MLR,MRR $
91  JUMP      LBL8 $
92  LABEL     LBL6 $

93  COND      LBL7,MODACC $
94  LABEL     LBL8 $
95  RBMG2     KLL/LLL $
96  CHKPNT    LLL $
97  COND      LBL7,REACT $
98  RBMG3     LLL,KLR,KRR/DM $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 12

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


 99  CHKPNT   DM $
100  RBMG4    DM,MLL,MLR,MRR/MR $
101  CHKPNT   MR $
102  LABEL    LBL7 $
103  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,DLT,,,NLFT,TRL,
              EED ,EQDYN/V,N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/
              V,N,NOFRL/V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $
104  SAVE     LUSETD,NODLT,NONLFT,NOTRL,NOUE,NOEED $
105  COND     ERROR2,NOEED $
106  PURGE    UEVT/NOUE/PNLH/NONLFT $
107  EQUIV    GO,GOD/NOUE/GM,GMD/NOUE $
108  CHKPNT   USETD,EQDYN,TFPOOL,DLT,TRL,EED,GOD,GMD,UEVT,NLFT,PNLH,SILD,
              GPLD $
109  PARAM    //C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 $
110  READ     KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N,
              NEIGV $
111  SAVE     NEIGV $
112  CHKPNT   LAMA,PHIA,MI,OEIGS $
113  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
114  OFP      OEIGS,,,,,//V,N,CARDNO $
115  SAVE     CARDNO $
116  COND     ERROR4,NEIGV $


117  OFP      LAMA,,,,,//V,N,CARDNO $
118  SAVE     CARDNO $
119  MTRXIN   CASECC,MATPOOL,EQDYN,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N,
              NOK2PP/V,N,NOM2PP/V,N,NOB2PP $
120  SAVE     NOK2PP,NOM2PP,NOB2PP $
121  PURGE    K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $
122  PARAM    //C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 12

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


123  EQUIV    M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDEMA $

124  CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,MDD $

125  GKAD     USETD,GM,GO,,,MAA,,K2PP,M2PP,B2PP/,,MDD,GMD,   GOD,K2DD,M2DD,
              B2DD/C,N,TRANRESP/C,N,DISP/C,N,MODAL/C,N,0.0/ C,N,0.0/C,N,0.0/
              V,N,NOK2PP/V,N,NOM2PP/V,N,NOB2PP/   V,N,MPCF1/V,N,SINGLE/V,N,
              OMIT/V,N,NOUE/C,N,-1/C,N,-1/   C,N,+1/V,Y,MODACC = -1 $

126  CHKPNT   MDD,GMD,GOD,K2DD,M2DD,B2DD $

127  GKAM     USETD,PHIA,MI,LAMA,OIT,M2DD,B2DD,K2DD,CASECC/MHH,BHH,KHH,PHIDH/
              V,N,NOUE/C,Y,LMODES=0/C,Y,LFREQ=0.0/C,Y,HFREQ=0.0/V,N,  NOM2PP/
              V,N,NOB2PP/V,N,NOK2PP/V,N,NONCUP/V,N,EMODE $

128  SAVE     NONCUP,EMODE $

129  CHKPNT   MHH,BHH,KHH,PHIDH $

130  COND     ERROR5,NOTRL $

131  PARAM    //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $

132  PARAM    //C,N,MPY/V,N,REPEATT/C,N,1/C,N,-1 $

133  JUMP     LBL13 $

134  LABEL    LBL13 $

135  PURGE    PNLH,OUHV1,OPNL1,OUHV2,OPNL2,XYPLTTA,OPP1,OQP1,OUPV1,OES1,OEF1,
              OPP2,OQP2,OUPV2,OES2,OEF2,PLOTX2,XYPLTT,OPPA,IQP1,IPHIP1,IES1,
              IEF1,OPPB,IQP2,IPHIP2,IES2,IEF2,ZQP2,ZUPV2,ZES2,ZEF2/NEVER $

136  CASE     CASECC,/CASEXX/C,N,TRAN/V,N,REPEATT/V,N,NOLOOP $

137  SAVE     REPEATT,NOLOOP $

138  CHKPNT   CASEXX $

139  PARAM    //C,N,MPY/V,N,NCOL/C,N,0/C,N,1 $


140  TRLG     CASEXX,USETD,DLT,SLT,BGPDT,SIL,CSTM,TRL,OIT,GMD,GOD,PHIDH, EST,
              MGG/PPT,PST,PDT,PD,PH,TOL/V,N,NOSET/V,N,PDEPDO/V,N,NCOL $

141  SAVE     PDEPDO,NOSET $

142  CHKPNT   PPT,PST,PDT,PD,PH,TOL $

143  EQUIV    PD,PDT/PDEPDO/PPT,PDT/NOSET $

144  CHKPNT   PDT $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 12

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


145  TRD      CASEXX,TRL,NLFT,DIT,KHH,BHH,MHH,PH/UHVT,PNLH/C,N,MODAL/ V,N,
              NOUE/V,N,NONCUP/V,N,NCOL/C,Y,ISTART $
146  SAVE     NCOL $
147  CHKPNT   UHVT,PNLH $
148  VDR      CASEXX,EQDYN,USETD,UHVT,TOL,YYCDB,PNLH/OUHV1,OPNL1/ C,N,
              TRANRESP/C,N,MODAL/C,N,0/V,N,NOH/V,N,NOP/V,N,EMODE $
149  SAVE     NOH,NOP $
150  CHKPNT   OUHV1,OPNL1 $
151  COND     LBL16,NOH $
152  SDR3     OUHV1,OPNL1,,,,/OUHV2,OPNL2,,,, $
153  OFP      OUHV2,OPNL2,,,,,//V,N,CARDNO $
154  SAVE     CARDNO $
155  CHKPNT   OPNL2,OUHV2 $
156  XYTRAN   XYCDB,OUHV2,OPNL2,,,/XYPLTTA/C,N,TRAN/C,N,HSET/V,N,PFILE/V,N,
              CARDNO $
157  SAVE     PFILE,CARDNO $
158  XYPLOT   XYPLTTA// $
159  LABEL    LBL16 $
160  PARAM    //C,N,AND/V,N,PJUMP/V,N,NOP/V,N,JUMPPLOT $
161  COND     LBL15,PJUMP $
162  PARAM    //C,N,NOT/V,N,NOMOD/V,Y,MODACC $
163  PARAM    //C,N,AND/V,N,MPJUMP/V,Y,MODACC/V,N,JUMPPLOT $

164  COND     LBDDRM,MPJUMP $
165  DDR1     UHVT,PHIDH/UDV1T $
166  CHKPNT   UDV1T $
167  COND     LBLMOD,MODACC $
168  DDR2     USETD,UDV1T,PDT,K2DD,B2DD,MDD,,LLL,DM/UDV2T,UEVT,PAF/  C,N,
              TRANRESP/V,N,NOUE/V,N,REACT/C,N,0 $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 12

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


169  CHKPNT   UDV2T,UEVT,PAF $
170  EQUIV    UDV2T,UDV1T/NOMOD $
171  CHKPNT   UDV1T $
172  LABEL    LBLMOD $
173  EQUIV    UDV1T,UPV/NOA $
174  COND     LBL14,NOA $
175  SDR1     USETD,,UDV1T,,,GOD,GMD,PST,KFS,,/UPV,,QP/C,N,1/C,N,DYNAMICS $
176  LABEL    LBL14 $
177  CHKPNT   UPV,QP $
178  SDR2     CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,BGPDT,TOL,QP,UPV,EST,XYCDB,
              PPT/OPP1,OQP1,OUPV1,OES1,OEF1,PUGV/C,N,TRANRESP $
179  SDR3     OPP1,OQP1,OUPV1,OES1,OEF1,/OPP2,OQP2,OUPV2,OES2,OEF2, $
180  JUMP     P2A $
181  LABEL    LBDDRM $
182  SDR1     USETD,,PHIDH,,,GOD,GMD,,KFS,,/PHIPH,,QPH/C,N,1/C,N,REIG $
183  SDR2     CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,,LAMA,QPH,PHIPH,EST,XYCDB,/
              ,IOP1,IPHIP1,IES1,IEF1,/C,N,MMREIG $
184  SDR2     CASEXX,,,,EQDYN,SILD,,,,TOL,,,,XYCDB,PPT/OPPA,,,,,/C,N,
              TRANRESP $
185  SDR3     OPPA,IQP1,IPHIP1,IES1,IEF1,/OPPB,IQP2,IPHIP2,IES2,IEF2, $
186  EQUIV    OPPB,OPP2/MODACC $
187  DDRMM    CASEXX,UHVT,TOL,IPHIP2,IQP2,IES2,IEF2,,EST,MPT,DIT/   ZUPV2,

              ZQP2,ZES2,ZEF2, $
188  EQUIV    ZUPV2,OUPV2/MODACC/ZQP2,OQP2/MODACC/ZEF2,OEF2/MODACC/ZES2,OES2/
              MODACC $
189  LABEL    P2A $
190  CHKPNT   OPP2,OQP2,OUPV2,OES2,OEF2 $
191  OFP      OUPV2,OPP2,OQP2,OEF2,OES2,//V,N,CARDNO $
192  SAVE     CARDNO $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 12

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


193  COND      P2,JUMPPLOT $
194  PLOT      PLTPAR,GPSETS,ELSETS,CASEXX,BGPDT,EQEXIN,SIL,,PUGV,,,/PLOTX2/
               V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
195  SAVE      PFILE $
196  PRTMSG    PLOTX2// $
197  LABEL     P2 $
198  XYTRAN    XYCDB,OPP2,OQP2,OUPV2,OES2,OEF2/XYPLTT/C,N,TRAN/C,N,PSET/V,N,
               PFILE/V,N,CARDNO $
199  SAVE      PFILE,CARDNO $
200  XYPLOT    XYPLTT// $
201  LABEL     LBL15 $
202  COND      FINIS,REPEATT $
203  REPT      LBL13,100 $
204  JUMP      ERROR3 $
205  JUMP      FINIS $
206  LABEL     ERROR3 $
207  PRTPARM   //C,N,-3/C,N,MDLTRD $
208  LABEL     ERROR2 $
209  PRTPARM   //C,N,-2/C,N,MDLTRD $
210  LABEL     ERROR1 $
211  PRTPARM   //C,N,-1/C,N,MDLTRD $

212  LABEL     ERROR4 $
213  PRTPARM   //C,N,-4/C,N,MDLTRD $
214  LABEL     ERROR5 $
215  PRTPARM   //C,N,-5/C,N,MDLTRD $
216  LABEL     FINIS $
217  END       $
```

3.13.2 Description of DMAP Operations for Modal Transient Response

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot output is requested.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plots are requested.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Grid Point Temperature Table.

24. TA1 generates element tables for use in matrix assembly and stress recovery.

26. Go to DMAP No. 210 and print error message if there are no structural elements.

31. EMG generates structural element stiffness and mass matrix tables and dictionaries for later assembly.

34. Go to DMAP No. 37 if no stiffness matrix is to be assembled.

35. EMA assembles stiffness matrix $[K^{x}_{gg}]$ and Grid Point Singularity Table.

38. Go to DMAP No. 210 and print error message if no mass matrix is to be assembled.

39. EMA assembles mass matrix $[M_{gg}]$.

41. Go to DMAP No. 44 if no weight and balance is requested.

42. GPWG generates weight and balance information.

43. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

45. Equivalence $[K^{x}_{gg}]$ to $[K_{gg}]$ if no general elements.

47. Go to DMAP No. 50 if no general elements.

48. SMA3 adds general elements to stiffness matrix $[K^{x}_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

52. GP4 generates flags defining members of various displacement sets (USET) and forms multi-point constraint equations $[R_g]\{u_g\} = 0$.

57. Go to DMAP No. 62 if general elements present.

58. GPSP determines if possible grid point singularities remain.

60. Go to DMAP No. 62 if no grid point singularities remain.

61. ØFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

63. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

65. Go to DMAP No. 70 if no multipoint constraints.

66. MCE1 partitions multipoint constraint equations $[R_g] = [R_m | R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

68. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \text{ and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m] .$$

71. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

73. Go to DMAP No. 76 if no single-point constraints.

74. SCE1 partitions out single-point constraints.

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right] .$$

77. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

78. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

80. Go to DMAP No. 85 if no omitted coordinates.

81. SMP1 partitions constrained stiffness matrix.

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

83. SMP2 partitions constrained mass matrix.

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o]$$

86. Equivalence $[K_{aa}]$ to $[K_{\ell\ell}]$ if free-body supports.

88. Go to DMAP No. 92 if no free-body supports.

89. RBMG1 partitions out free-body supports.

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] \quad \text{and} \quad [M_{aa}] = \left[\begin{array}{c|c} M_{\ell\ell} & M_{\ell r} \\ \hline M_{r\ell} & M_{rr} \end{array}\right]$$

91. Go to DMAP No. 94 because supports are present and mode acceleration is used.

93. Go to DMAP No. 102 if no request for mode acceleration data recovery.

95. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

97. Go to DMAP No. 102 if no free-body supports.

98. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}] \quad ,$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D] \quad ,$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||}$$

100. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

103. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers (GPLD), including extra points introduced for dynamic analysis (SILD), and prepares Transfer Function Pool (TFPØØL), Dynamics Load Table (DLT), Nonlinear Function Table (NLFT), and Transient Response List (TRL).

105. Go to DMAP No. 208 and print error message if no Eigenvalue Extraction Data.

107. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

110. READ extracts real eigenvalues from the equation

$$[K_{aa} - \lambda M_{aa}]\{u_a\} = 0 \quad ,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized and computes rigid body eigenvectors

$$[\phi_{ao}] = \begin{bmatrix} D_m \phi_{ro} \\ \hline \phi_{ro} \end{bmatrix} ,$$

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass.

114. ØFP formats the summary of eigenvalue extraction information (ØEIGS) prepared by READ and places it on the system output file for printing.

116. Go to DMAP No. 212 and print error message if no eigenvalues found.

117. ØFP formats the eigenvalues (LAMA) prepared by READ and places them on the system output file for printing.

119. MTRXIN selects the direct input matrices $[K^2_{pp}]$, $[M^2_{pp}]$ and $[B^2_{pp}]$.

123. Equivalence $[M^2_{pp}]$ to $[M^2_{dd}]$, $[B^2_{pp}]$ to $[B^2_{dd}]$ and $[K^2_{pp}]$ to $[K^2_{dd}]$ if no constraints applied, and $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points.

125. GKAD applies constraints to direct input matrices $[K^2_{pp}]$, $[M^2_{pp}]$ and $[B^2_{pp}]$, forming $[K^2_{dd}]$, $[M^2_{dd}]$ and $[B^2_{dd}]$.

127. GKAM assembles stiffness mass and damping matrices in modal coordinates for use in Transient Response

$$[K_{hh}] = [k] + [\phi^T_{dh}][K^2_{dd}][\phi_{dh}] ,$$

$$[M_{hh}] = [m] + [\phi^T_{dh}][M^2_{dd}][\phi_{dh}] ,$$

$$[B_{hh}] = [b] + [\phi^T_{dh}][B^2_{dd}][\phi_{dh}] ,$$

where

m_i = modal masses

$b_i = m_i \, 2\pi \, f_i \, g(f_i)$

$k_i = m_i \, 4\pi^2 \, f_i^2$

and all matrices are real.

130. Go to DMAP No. 214 and print error message if no Transient Response List.

133. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

134. Beginning of loop for additional dynamic load sets.

136. CASE extracts user requests from CASECC for current loop.

140. TRLG generates matrices of loads versus time. $\{P_p^t\}$, $\{P_s^t\}$, and $\{P_d^t\}$ are generated with one column per output time step. $\{P_d\}$ and $\{P_h\}$ are generated with one column per solution time step, and the Transient Output List (TØL) is a list of output time steps.

143. Equivalence $\{P_d\}$ to $\{P_d^t\}$ if the output times are the same as the solution times and $\{P_d^t\}$ to $\{P_p^t\}$ if the d and p sets are the same.

145. TRD forms the linear, $\{P_d\}$, and nonlinear, $\{P_d^{n\ell}\}$, dynamic load vectors and integrates the equations of motion using the standard starting procedure over specified time periods to solve for the displacements, velocities and accelerations, using the following equation

$$[M_{hh}p^2 + B_{hh}p + K_{hh}]\{u_h\} = \{P_h\} + \{P_h^{n\ell}\} \quad .$$

148. VDR prepares displacements, velocities and accelerations, sorted by time step, for output using only the extra points introduced for dynamic analysis and modal coordinates (solution points).

151. Go to DMAP No. 159 if no output request for the solution points.

152. SDR3 sorts the solution point displacements, velocities, accelerations and nonlinear load vectors by point number.

153. ØFP formats the requested solution point displacements, velocities, accelerations and non-linear load vectors prepared by SDR3 and places them on the system output file for printing.

155. XYTRAN prepares the input for X-Y plotting of the solution point displacements, velocities, accelerations and nonlinear load vectors vs time.

158. XYPLØT prepares requested X-Y plots of the solution point displacements, velocities, accelerations and nonlinear load vectors vs time.

161. Go to DMAP No. 201 if no output request involving dependent degrees of freedom, forces and stresses, or deformed structure plot.

165. DDR1 transforms the solution vector displacements from modal to physical coordinates

$$\{u_d\} = [\phi_{dh}]\{u_h\} \quad .$$

167. Go to DMAP No. 172 if mode acceleration technique not requested.

168. DDR2 calculates an improved displacement vector using the mode acceleration technique, if requested.

173. Equivalence $\{u_d\}$ to $\{u_p\}$ if no constraints applied.

174. Go to DMAP No. 176 if no constraints applied.

175. SDR1 recovers dependent components of displacements

$$\{u_o\} = [G_o^d]\{u_d\} \qquad \left\{\begin{array}{c} u_d \\ \hline u_o \end{array}\right\} = \{u_f + u_e\} \quad .$$

$$\left\{\begin{array}{c} u_f + u_e \\ \hline u_s \end{array}\right\} = \{u_n + u_e\} \ , \qquad \{u_m\} = [G_m^d]\{u_n + u_e\} \ ,$$

$$\left\{\begin{array}{c} u_n + u_e \\ \hline u_m \end{array}\right\} = \{u_p\}$$

and recovers single-point forces of constraint $\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\}$.

178. SDR2 calculates element forces (ØEF1) and stresses (ØES1) and prepares load vectors (ØPP1), displacement, velocity and acceleration vectors (ØUPV1) and single-point forces of constraint (ØQP1) for output and the translation components of the displacement vector (PUGV) sorted by time step.

179. SDR3 prepares requested output sorted by point number or element number.

180. Go to DMAP No. 189 because no mode acceleration requested.

181. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o^d]\{\phi_h\} \ , \qquad \left\{\begin{array}{c} \phi_h \\ \hline \phi_o \end{array}\right\} = \{\phi_f + u_e\}$$

$$\left\{\begin{array}{c} \phi_f + u_e \\ \hline \phi_s \end{array}\right\} = \{\phi_n + u_e\} \qquad \{\phi_m\} = [G_m^d]\{\phi_n + u_e\}$$

$$\left\{\begin{array}{c} \phi_n + u_e \\ \hline \phi_m \end{array}\right\} = \{\phi_g + u_e\} = \{\phi_p\}$$

and recovers single-point forces of constraint

$$\{q_s\} = [K_{fs}]^T\{\phi_f\} \ .$$

183. SDR2 calculates element forces (IEF1) and stresses (IES1) and prepares eigenvectors (IPHIP1) and single-point forces of constraint (IQP1) for output sorted by time step.

184. SDR2 prepares load vectors for output (ØPPA) sorted by time step.

185. SDR3 prepares requested output sorted by point number or element number.

186. Equivalence ØPPB to ØPP2 if mode acceleration requested.

187. DDRMM prepares a subset of the element forces (ZEF2) and stresses (ZES2), displacement vectors (ZUPV2) and single-point forces of constraint (ZQP2) solutions for output sorted by point number of element number.

188. Equivalence ZUPV2 to ØUPV2, ZQP2 to ØQP2, ZES2 to ØES2, and ZEF2 to ØEF2 if mode acceleration requested.

191. ØFP formats requested output prepared by SDR3 (no mode acceleration) or DDRMM (with mode acceleration) and places it on the system output file for printing.

193. Go to DMAP No. 197 if no deformed structure plots requested.

194. PLØT prepares all requested deformed structure and contour plots.

196. PRTMSG prints plotter data, engineering data, and contour data for each deformed plot generated.

198. XYTRAN prepares the input for requested X-Y plots.

200. XYPLØT prepares requested X-Y plots of displacements, velocities, accelerations, forces, stresses, loads or single-point forces of constraint vs time.

202. Go to DMAP No. 216 and make normal exit if no additional dynamic load sets need to be processed.

203. Go To DMAP No. 134 if additional dynamic load sets need to be processed.

204. Go to DMAP No. 206 and print error message if more than 100 loops.

205. Go to DMAP No. 216 and make normal exit.

207. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

209. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

211. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

213. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

215. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 5 - TRANSIENT RESPØNSE LIST REQUIRED FØR TRANSIENT RESPØNSE CALCULATIØNS.

3.13.3 Automatic Output for Modal Transient Response

The Eigenvalue Summary Table and the Eigenvalue Analysis Summary, as described under Normal Mode Analysis, are automatically printed. All real eigenvalues extracted are included even though not all are used in the modal formulation.

3.13.4 Case Control Deck and Parameters for Modal Transient Response

The following items related to subcase definition and data selection must be considered in addition to the list presented with Direct Transient Response:

1. METHØD must appear above the subcase level to select an EIGR card that exists in the Bulk Data Deck.
2. All of the eigenvectors used in the modal formulation must be determined in a single execution.
3. An SPC set must be selected above the subcase level unless the model is a free body or all constraints are specified on GRID cards, Scalar Connection cards or with General Elements.
4. SDAMPING must be used to select a TABDMP1 table if structural damping is desired.

Output that may be requested is the same as that described under Direct Transient Response. Output for SØLUTIØN points will have the modal coordinates identified by the mode number determined in Real Eigenvalue Analysis.

The eigenvectors used in the modal formulation may be obtained for the SØLUTIØN points by using the ALTER feature to print the matrix of eigenvectors following the execution of READ. The eigenvectors for all points in the model may be obtained by running the problem initially on the Normal Mode Analysis rigid format or by making a modified restart using the Normal Mode Analysis rigid format.

The following parameters are used in Modal Transient Response:

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

4. LFREQ and HFREQ - required unless LMØDES is used. The values of these parameters give the frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation.

5. LMØDES - required unless LFREQ and HFREQ are used. The integer value of this parameter is the number of lowest modes to be used in the modal formulation.

6. MØDACC - optional - A positive integer value of this parameter causes the Dynamic Data Recovery module to use the mode acceleration method. Not recommended for use in hydroelastic problems.

7. ISTART - optional - A positive value of this parameter will cause the TRD module to use the second (or alternate) starting method (see Section 11.3 of the Theoretical Manual). The alternate starting method is recommended when initial accelerations are significant and when the mass matrix is non-singular.

3.13.5 Optional Diagnostic Output for FEER

Special detailed information resulting from requesting DIAG 16 in the Executive Control Deck is the same as described under Normal Modes analysis (see Section 3.4.6).

3.13.6 The APPEND Feature

The APPEND feature can be used for real eigenvalue extraction in Modal Transient Response. See Section 3.4.7 for details.

3.13.7 The CONTINUE Feature

The CONTINUE feature can be used for coupled transient analysis in Modal Transient Response. See Section 3.10.4 for details.

3.14 NORMAL MODES WITH DIFFERENTIAL STIFFNESS

3.14.1 DMAP Sequence for Normal Modes with Differential Stiffness

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 13

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN    NO.13 NORMAL MODES WITH DIFFERENTIAL STIFFNESS - SERIES P $

    2  FILE     LAMA=APPEND/PHIA=APPEND $

    3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT $

    4  SAVE     LUSET $

    5  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

    6  GP2      GEOM2,EQEXIN/ECT $

    7  CHKPNT   ECT $

    8  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

    9  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

   10  COND     P1,NOPCDB $

   11  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/  V,N,
                JUMPPLOT=-1 $

   12  SAVE     NSIL,JUMPPLOT $

   13  PRTMSG   PLTSETX// $

   14  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

   15  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

   16  COND     P1,JUMPPLOT $

   17  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

   18  SAVE     JUMPPLOT,PLTFLG,PFILE $


   19  PRTMSG   PLOTX1// $

   20  LABEL    P1 $

   21  CHKPNT   PLTPAR,GPSETS,ELSETS $

   22  GP3      GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $

   23  CHKPNT   SLT,GPTT $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 13

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


24  TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,,,/V,N,LUSET/V,N,
              NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

25  SAVE      NOSIMP,NOGENL,GENEL $

26  COND      ERROR1,NOSIMP $

27  PURGE     OGPST/GENEL $

28  CHKPNT    EST,GPECT,GEI,OGPST $

29  PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

30  PARAM     //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

31  EMG       EST,CSTM,MPT,DIT,GEOM2,,/KELM,KDICT,MELM,MDICT,,,/V,N,NOKGGX/ V,
              N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
              CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
              CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

32  SAVE      NOKGGX,NOMGG $

33  CHKPNT    KELM,KDICT,MELM,MDICT $

34  COND      JMPKGG,NOKGGX $

35  EMA       GPECT,KDICT,KELM/KGGX,GPST $

36  CHKPNT    KGGX,GPST $

37  LABEL     JMPKGG $

38  COND      ERROR5,NOMGG $

39  EMA       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

40  CHKPNT    MGG $

41  COND      LBL1,GRDPNT $


42  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS $

43  OFP       OGPWG,,,,,// $

44  LABEL     LBL1 $

45  EQUIV     KGGX,KGG/NOGENL $

46  CHKPNT    KGG $

47  COND      LBL11,NOGENL $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 13

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


48  (SMA3)    GET,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
49  CHKPNT    KGG $
50  LABEL     LBL11 $
51  PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
52  (GP4)     CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N,LUSET/
              V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
              N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
53  SAVE      MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $
54  COND      ERROR6,NOL $
55  PARAM     //C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT $
56  PURGE     GM/MPCF1/GO,KOO,LOO,PO,UOOV,RUOV/OMIT/PS,KFS,KSS/SINGLE/  QG/
              NOSR $
57  CHKPNT    GM,RG,GO,KOO,LOO,PO,UOOV,RUOV,YS,PS,KFS,KSS,USET,ASET,QG $
58  COND      LBL40,REACT $
59  JUMP      ERROR2 $
60  LABEL     LBL40 $
61  COND      LBL4,GENEL $
62  (GPSP)    GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
63  SAVE      NOGPST $
64  COND      LBL4,NOGPST $
65  DEF       OGPST,,,,,// $
66  LABEL     LBL4 $

67  EQUIV     KGG,KNN/MPCF1 $
68  CHKPNT    KNN $
69  COND      LBL2,MPCF2 $
70  (MCE1)    USET,RG/GM $
71  CHKPNT    GM $
72  (MCE2)    USET,GM,KGG,,,/KNN,,, $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 13

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


73   CHKPNT    KNN $
74   LABEL     LBL2 $
75   EQUIV     KNN,KFF/SINGLE $
76   CHKPNT    KFF $
77   COND      LBL3,SINGLE $
78   SCE1      USET,KNN,,,/KFF,KFS,KSS,,, $
79   CHKPNT    KFS,KSS,KFF $
80   LABEL     LBL3 $
81   EQUIV     KFF,KAA/OMIT $
82   CHKPNT    KAA $
83   COND      LBL5,OMIT $
84   SMP1      USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $
85   CHKPNT    GO,KAA,KOO,LOO $
86   LABEL     LBL5 $
87   PRMG2     KAA/LLL $
88   CHKPNT    LLL $
89   SSG1      SLT,BGPDT,CSTM,SIL,EST,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/ V,N,
               LUSET/C,N,1 $
90   CHKPNT    PG $
91   EQUIV     PG,PL/NOSET $
92   CHKPNT    PL $


93   COND      LBL10,NOSET $
94   SSG2      USET,GM,YS,KFS,GO,,PG/,PO,PS,PL $
95   CHKPNT    PO,PS,PL $
96   LABEL     LBL10 $
97   SSG3      LLL,KAA,PL,LOO,KOO,PO/ULV,UOOV,RULV,RUOV/V,N,OMIT/V,Y,IRES=-1/
               C,N,1/V,N,EPSI $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 13

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


 98  SAVE      EPSI $
 99  CHKPNT    ULV,UOOV,RULV,RUOV $
100  COND      LBL9,IRES $
101  MATGPR    GPL,USET,SIL,RULV//C,N,L $
102  MATGPR    GPL,USET,SIL,RUOV//C,N,O $
103  LABEL     LBL9 $
104  SDR1      USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,/UGV,PGG,QG/C,N,1/C,N,
               BKLO $
105  CHKPNT    UGV,QG,PGG $
106  SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QG,UGV,EST,,PGG/
               OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,BKLO $
107  PARAM     //C,N,MPY/V,N,CARDNO/C,N,O/C,N,O $
108  OFP       OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $
109  SAVE      CARDNO $
110  COND      P2,JUMPPLOT $
111  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,,GPECT,OES1/
               PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
112  SAVE      PFILE $
113  PRTMSG    PLOTX2// $
114  LABEL     P2 $
115  TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/X1,X2,X3,ECPT,GPCT/V,N,LUSET/   V,
               N,NOSIMP/C,N,O/V,N,NOGENL/V,N,GENEL $


116  DSMG1     CASECC,GPTT,SIL,EDT,UGV,CSTM,MPT,ECPT,GPCT,DIT/KDGG/  V,N,
               DSCOSET $
117  SAVE      DSCOSET $
118  CHKPNT    KDGG $
119  EQUIV     KDGG,KDNN/MPCF2 / MGG,MNN/MPCF2 $
120  CHKPNT    KDNN,MNN $
121  COND      LBL2D,MPCF2 $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 13

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


122 (MCE2)    USET,GM,KDGG,MGG,,/KDNN,MNN,, $
123  CHKPNT   KDNN,MNN $
124  LABEL    LBL2D $
125  EQUIV    KDNN,KDFF/SINGLE / MNN,MFF/SINGLE $
126  CHKPNT   KDFF,MFF $
127  COND     LBL3D,SINGLE $
128 (SCE1)    USET,KDNN,MNN,,/KDFF,KDFS,KDSS,MFF,, $
129  CHKPNT   KDFF,KDFS,KDSS,MFF $
130  LABEL    LBL3D $
131  EQUIV    KDFF,KDAA/OMIT / MFF,MAA/OMIT $
132  CHKPNT   KDAA,MAA $
133  COND     LBL5D,OMIT $
134 (SMP2)    USET,GO,KDFF/KDAA $
135 (SMP2)    USET,GO,MFF/MAA $
136  CHKPNT   KDAA,MAA $
137  LABEL    LBL5D $
138  PARAM    //C,N,ADD/V,N,DSCOSET/C,N,-1/C,N,0 $
139  EQUIV    PL,PBL/DSCOSET/PS,PBS/DSCOSET/YS,YBS/DSCOSET/UOOV,UBOOV/
              DSCOSET $
140  CHKPNT   PBL,PBS,YBS,UBOOV $
141  PARAM    //C,N,MPY/V,N,NDSKIP/C,N,0/C,N,0 $

142 (DSMG2)    MPT,KAA,KDAA,KFS,KDFS,KSS,KDSS,PL,PS,YS,UOOV/KBLL,KBFS,KBSS,
              PBL,PBS,YBS,UBOOV/V,N,NDSKIP/ V,N,REPEATD/ V,N,DSCOSET $
143  SAVE     NDSKIP,REPEATD $
144  CHKPNT   KBLL,KBFS,KBSS,PBL,PBS,YBS,UBOOV $
145 (RBMG2)    KBLL/LBLL/V,N,POWER/V,N,DET $
146  SAVE     DET,POWER $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 13

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


147  CHKPNT   LBLL $

148  PRTPARM  //C,N,O/C,N,DET $

149  PRTPARM  //C,N,O/C,N,POWER $

150  SSG3     LBLL,KBLL,PBL,,,,/UBLV,,RUBLV,/C,N,-1/V,Y,IRES/V,N,NOSKIP/  V,N,
              EPSI $

151  SAVE     EPSI $

152  CHKPNT   UBLV,RUBLV $

153  COND     LBL9D,IRES $

154  MATGPR   GPL,USET,SIL,RUBLV//C,N,L $

155  LABEL    LBL9D $

156  SDR1     USET,,UBLV,UBDOV,YRS,GO,GM,PBS,KBFS,KBSS,/UBGV,,QBG/V,N,NOSKIP/
              C,N,DS1 $

157  CHKPNT   UBGV,QPG $

158  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QBG,UBGV,EST,,/,
              OQBG1,OUBGV1,OESB1,OEFB1,PUBGV1/C,N,DS1 $

159  OFP      OQBG1,OUBGV1,OESB1,OEFB1,,,//V,N,CARDNO $

160  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,,,,,,,EED,EQDYN/V,N,
              LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/  V,
              N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $

161  SAVE     NOEED $

162  COND     ERROR3,NOEED $

163  CHKPNT   EED $

164  PARAM    //C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 $


165  READ     KBLL,MAA,,,EED,USET,CASECC/LAMA,PHIA,,OEIGS/C,N,MODES/ V,N,
              NEIGV/C,N,3 $

166  SAVE     NEIGV $

167  CHKPNT   LAMA,PHIA,OEIGS $

168  OFP      OEIGS,,,,,//V,N,CARDNO $

169  SAVE     CARDNO $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 13

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


170  COND      ERROR4,NEIGV $
171  DEP       LAMA,,,,,,//V,N,CARDNO $
172  SAVE      CARDNO $
173  SOP1      USET,,PHIA,,,GO,GM,,KOFS,,/PHIG,,RQG/C,N,1/C,N,REIG $
174  CHKPNT    PHIG,RQG $
175  CASE1     CASECC,/CASEXX/C,N,TRANRESP/V,N,REPEAT=3/V,N,LOOP $
176  SOP2      CASEXX,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDT,LAMA,RQG,PHIG,EST,,/,
               ORQG1,OPHIG,ORES1,OREF1,PPHIG/C,N,REIG $
177  DEP       OPHIG,ORQG1,OREF1,ORES1,,,//V,N,CARDNO $
178  SAVE      CARDNO $
179  COND      P3,JUMPPLOT $
180  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,PPHIG,GPECT,
               ORES1/PLOTX3/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,
               PETLE $
181  SAVE      PETLE $
182  PRTMSG    PLOTX3// $
183  LABEL     P3 $
184  JUMP      FINIS $
185  LABEL     ERROR1 $
186  PRTPARM   //C,N,-1/C,N,NMDS $
187  LABEL     ERROR2 $
188  PRTPARM   //C,N,-2/C,N,NMDS $


189  LABEL     ERROR3 $
190  PRTPARM   //C,N,-3/C,N,NMDS $
191  LABEL     ERROR4 $
192  PRTPARM   //C,N,-4/C,N,NMDS $
193  LABEL     ERROR5 $
194  PRTPARM   //C,N,-5/C,N,NMDS $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 13

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


195  LABEL    ERROR6 $
196  PRTPARM  //C,N,-6/C,N,NMDS $
197  LABEL    FINIS $
198  END      $
```

3.14.2 Description of DMAP Operations for Normal Modes with Differential Stiffness.

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot output is requested.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plots requested.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Static Loads Table and Grid Point Temperature Table.

24. TA1 generates element tables for use in matrix assembly and stress recovery.

26. Go to DMAP No. 185 and print error message if no elements have been defined.

31. EMG generates structural element matrix stiffness and mass tables and dictionaries for later assembly.

34. Go to DMAP No. 37 if no stiffness matrix is to be assembled.

35. EMA assembles stiffness matrix $[K^{x}_{gg}]$ and Grid Point Singularity Table.

38. Go to DMAP No. 193 and print error message if no mass matrix exists.

39. EMA assembles mass matrix $[M_{gg}]$.

41. Go to DMAP No. 44 if no weight and balance is requested.

42. GPWG generates weight and balance information.

43. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

45. Equivalence $[K^{x}_{gg}]$ to $[K_{gg}]$ if no general elements.

47. Go to DMAP No. 50 if no general elements.

48. SMA3 adds general elements to $[K^{x}_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

52. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

54. Go to DMAP No. 195 and print error message if no independent degrees of freedom are defined.

58. Go to DMAP No. 60 if no support cards.

59. Go to DMAP No. 187 and print error message if free-body supports are present.

61. Go to DMAP No. 66 if general elements present.

62. GPSP determines if possible grid point singularities remain.

64. Go to DMAP No. 66 if no grid point singularities remain.

65. ØFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

67. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

69. Go to DMAP No. 74 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

70. MCE1 partitions multipoint constraint equations $[R_g] = [R_m | R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

72. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

75. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

77. Go to DMAP No. 80 if no single-point constraints.

78. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right]$$

81. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

83. Go to DMAP No. 86 if no omitted coordinates.

84. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}aa] + [K_{oa}^T][G_o]$.

87. RBMG2 decomposes constrained stiffness matrix $[K_{aa}] = [L_{\ell\ell}][U_{\ell\ell}]$.

89. SSG1 generates static load vectors $\{P_g\}$.

91. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

93. Go to DMAP No. 96 if no constraints applied.

94. SSG2 applies constraints to static load vectors

$$\{P_g\} = \begin{Bmatrix} \bar{P}_n \\ \hline P_m \end{Bmatrix} , \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\} ,$$

$$\{P_n\} = \begin{Bmatrix} \bar{P}_f \\ \hline P_s \end{Bmatrix} , \qquad \{P_f\} = \{\bar{P}_f\} + [K_{fs}]\{Y_s\} ,$$

$$\{P_f\} = \begin{Bmatrix} P_a \\ \hline P_o \end{Bmatrix} \text{ and } \qquad \{P_\ell\} = \{P_a\} + [G_o^T]\{P_o\} .$$

97. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell\} ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\} ,$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{\ell\ell}]\{u_\ell\}$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}} ,$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\} ,$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o\}}$$

100. Go to DMAP No. 103 if residual vectors are not to be printed.

101. MATGPR prints residual vector for independent coordinates (RULV).

102. MATGPR prints residual vector for omitted coordinates (RUØV).

104. SDR1 recovers dependent displacements

$$\{u_o\} = [G_o]\{u_\ell\} + \{u_o^o\} \quad ,$$

$$\begin{Bmatrix} u_a \\ \hline u_o \end{Bmatrix} = \{u_f\} \quad , \qquad \begin{Bmatrix} u_f \\ \hline Y_s \end{Bmatrix} = \{u_n\} \quad ,$$

$$\{u_m\} = [G_m]\{u_n\} \quad , \qquad \begin{Bmatrix} u_n \\ \hline u_m \end{Bmatrix} = \{u_g\} \quad ,$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\} \quad .$$

106. SDR2 calculates element forces (ØEF1) and stresses (ØES1) and prepares load vectors (ØPG1), displacement vectors (ØUGV1), and single-point forces of constraint (ØQG1) for output and translation components of the displacement vector (PUGV1) for the static solution.

108. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

110. Go to DMAP No. 114 if no static deformed structure plots are requested.

111. PLØT generates all requested static deformed structure and contour plots.

113. PRTMSG prints plotter data, engineering data, and contour data for each deformed static solution plot generated.

115. TA1 generates element tables for use in matrix assembly for differential stiffness matrix.

116. DSMG1 generates differential stiffness matrix $[K_{gg}^d]$.

119. Equivalence $[K_{gg}^d]$ to $[K_{nn}^d]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

121. Go to DMAP No. 124 if no multipoint constraints.

122. MCE2 partitions differential stiffness matrix

$$[K_{gg}^d] = \left[\begin{array}{c|c} \bar{K}_{nn}^d & K_{nm}^d \\ \hline K_{mn}^d & K_{mm}^d \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}^d] = [\bar{K}_{nn}^d] + [G_m^T][K_{mn}^d] + [K_{mn}^d][G_m] + [G_m^T][K_{mm}^d][G_m] \quad .$$

125. Equivalence $[K^d_{nn}]$ to $[K^d_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

127. Go to DMAP No. 130 if no single-point constraints.

128. SCE1 partitions out single-point constraints

$$[K^d_{nn}] = \begin{bmatrix} K^d_{ff} & K^d_{fs} \\ K^d_{sf} & K^d_{ss} \end{bmatrix} \quad \text{and} \quad [M_{nn}] = \begin{bmatrix} M_{ff} & M_{fs} \\ M_{sf} & M_{ss} \end{bmatrix}$$

131. Equivalence $[K^d_{ff}]$ to $[K^d_{aa}]$ and $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

133. Go to DMAP No. 137 if no omitted coordinates.

134. SMP2 partitions constrained differential stiffness matrix

$$[K^d_{ff}] = \begin{bmatrix} \bar{K}^d_{aa} & K^d_{ao} \\ K^d_{oa} & K^d_{oo} \end{bmatrix}$$

and performs matrix reduction $[K^d_{aa}] = [\bar{K}^d_{aa}] + [K^d_{ao}][G_o]$.

135. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \begin{bmatrix} \bar{M}_{aa} & M_{ao} \\ M_{oa} & M_{oo} \end{bmatrix}$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M^T_{oa}][G_o] + [G^T_o][M_{oa}] + [G^T_o][M_{oo}][G_o] .$$

139. Equivalence $\{P_\ell\}$ to $\{P^b_\ell\}$, $\{P_s\}$ to $\{P^b_s\}$, $\{Y_s\}$ to $\{Y^b_s\}$and $\{u^o_o\}$ to $\{u^{ob}_o\}$ if a scale factor is not specified on a DSFACT card.

142. DSMG2 adds partitions of stiffness matrix to similar partitions of differential stiffness matrix

$$[K^b_{\ell\ell}] = [K_{aa}] + \beta[K^d_{aa}] ,$$

$$[K^b_{fs}] = [K_{fs}] + \beta[K^d_{fs}] \text{ and}$$

$$[K^b_{ss}] = [K_{ss}] + \beta[K^d_{ss}]$$

and multiplies partitions of load vectors and displacement vectors by the value of differential stiffness scale factor (β)

$$\{P_\ell^b\} = \beta\{P_\ell\} \quad , \qquad \{P_s^b\} = \beta\{P_s\} \quad ,$$

$$\{Y_s^b\} = \beta\{Y_s\} \text{ and} \qquad \{u_o^{bo}\} = \beta\{u_o^o\} \quad .$$

145. RBMG2 decomposes the combined differential stiffness matrix and elastic stiffness matrix

$$[K_{\ell\ell}^b] = [L_{\ell\ell}^b][U_{\ell\ell}^b] \quad .$$

148. PRTPARM prints the scaled value of the determinant of the combined differential stiffness matrix and elastic stiffness matrix.

149. PRTPARM prints the scale factor (power of ten) of the determinant of the combined differential stiffness matrix and the elastic stiffness matrix.

150. SSG3 solves for displacements of independent coordinates for the value of differential stiffness scale factor (β)

$$\{u_\ell^b\} = [K_{\ell\ell}^b]^{-1}\{P_\ell^b\}$$

and calculates residual vector (RBULV) and residual vector error ratio for the value of differential stiffness load factor

$$\{\delta P_\ell^b\} = \{P_\ell^b\} - [K_{\ell\ell}^b]\{u_\ell^b\} \quad ,$$

$$\varepsilon_\ell^b = \frac{\{u_\ell^b\}^T\{\delta P_\ell^b\}}{\{P_\ell^b\}^T\{u_\ell^b\}}$$

153. Go to DMAP No. 155 if residual vector for the value of differential stiffness load factor is not to be printed.

154. MATGPR prints residual vector for the value of differential stiffness load factor.

156. SDR1 recovers dependent displacements for the value of differential stiffness scale factor

$$\{u_o^b\} = [G_o]\{u_\ell^b\} + \{u_o^{ob}\} \quad , \qquad \begin{Bmatrix} u_\ell^b \\ \hline u_o^b \end{Bmatrix} = \{u_f^b\} \quad ,$$

$$\begin{Bmatrix} u_f^b \\ \hline Y_s^b \end{Bmatrix} = \{u_n^b\} \quad , \qquad \{u_m^b\} = [G_m]\{u_n^b\} \quad ,$$

$$\begin{Bmatrix} u_n^b \\ \hline u_m^b \end{Bmatrix} = \{u_g^b\}$$

and recovers single-point forces of constraint for the value of differential stiffness scale factor

$$\{q_s^b\} = -\{P_s^b\} + [K_{sf}^b]\{u_f^b\} + [K_{ff}^b]\{Y_s^b\} \quad .$$

158. SDR2 calculates element forces (ØEFB1) and stresses (ØESB1) and prepares displacement vectors (ØUBGV1) and single-point forces of constraint (ØQBG1) for output and the translation components of the displacement vector (PUBGV1) for the differential stiffness solution.

159. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

160. DPD extracts Eigenvalue Extraction Data from Dynamics data block.

162. Go to DMAP No. 189 and print error message if no Eigenvalue Extraction Data.

165. READ extracts real eigenvalues from the equation

$$[K_{\ell\ell}^b - \lambda M_{aa}]\{u_a\} = 0 \quad ,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized, computes rigid body eigenvectors

$$[\phi_{ao}] = \frac{D\ \phi_{ro}}{\phi_{ro}}$$

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass.

168. ØFP formats the summary of eigenvalue extraction information (ØEIGS) prepared by READ and places it on the system output file for printing.

170. Go to DMAP No. 191 and exit if no eigenvalues found.

171. ØFP formats the eigenvalues prepared by READ and places them on the system output file for printing.

173. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o]\{\phi_a\} \quad , \qquad \begin{Bmatrix} \phi_a \\ -- \\ \phi_o \end{Bmatrix} = \{\phi_f\} \quad ,$$

$$\begin{Bmatrix} \phi_f \\ -- \\ \phi_s \end{Bmatrix} = \{\phi_n\} \quad , \qquad \{\phi_m\} = [G_m]\{\phi_n\} \quad ,$$

$$\left\{\begin{matrix}\phi_n \\ \hline \phi_m\end{matrix}\right\} = \{\phi_g\}$$

and recovers single-point forces of constraint $\{q_s\} = [K_{fs}^T]\{\phi_f\}$.

176. SDR2 calculates element forces (ØBEF1) and stresses (ØBES1) and prepares eigenvectors (ØPHIG) and single-point forces of constraint (ØBQG1) for output and the translation components of the eigenvectors (PPHIG) for the normal mode solution.

177. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

179. Go to DMAP No. 183 if no deformed real eigenvalue structure plots are requested.

180. PLØT generates all requested deformed real eigenvalue structure and contour plots.

182. PRTMSG prints plotter data, engineering data, and contour data for each deformed plot generated.

184. Go to DMAP No. 197 and make normal exit.

186. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 1 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

188. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 2 - FREE BØDY SUPPØRTS NØT ALLØWED.

190. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 3 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

192. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 4 - NØ EIGENVALUE FØUND.

194. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 5 - MASS MATRIX REQUIRED FØR REAL EIGENVALUE ANALYSIS.

196. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 6 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

3.14.3 Automatic Output for Normal Modes with Differential Stiffness

Each eigenvalue is identified with a mode number determined by sorting the eigenvalues by their magnitude. The following summary of the eigenvalues extracted is automatically printed:

1. Mode Number
2. Extraction Order
3. Eigenvalue
4. Radian Frequency
5. Cyclic Frequency
6. Generalized Mass
7. Generalized Stiffness

The following summary of the eigenvalue analysis performed, using the Inverse Power method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of starting points used.
3. Number of starting point moves.
4. Number of triangular decompositions.
5. Number of vector iterations.
6. Reason for termination.
 (1) Two consecutive singularities encountered while performing triangular decomposition.
 (2) Four shift points while tracking a single root.
 (3) All eigenvalues found in the frequency range specified.
 (4) Three times the number of roots estimated in the frequency range have been extracted.
 (5) All eigenvalues that exist in the problem have been found.
 (6) The number of roots desired have been found.
 (7) One or more eigenvalues have been found outside the frequency range specified.
 (8) Insufficient time to find another root.
 (9) Unable to converge.
7. Largest off-diagonal modal mass term and the number failing the criteria.

The following summary of the eigenvalue analysis performed, using the Determinant method, is automatically printed:

The following parameters are used in Normal Mode Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - the terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA.

3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of couples mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

3.14.5 Optional Diagnostic Output for FEER

Special detailed information resulting from requesting DIAG 16 in the Executive Control Deck is the same as described under Normal Modes analysis (see Section 3.4.6).

3.14.6 The APPEND Feature

The APPEND feature can be used for real eigenvalue extraction in Normal Modes with Differential Stiffness. See Section 3.4.7 for details.

3.15 STATIC ANALYSIS USING CYCLIC SYMMETRY

3.15.1 DMAP Sequence for Static Analysis Using Cyclic Symmetry

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 14

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN    NO.14 STATIC ANALYSIS WITH CYCLIC SYMMETRY - SERIES P $

    2  FILE     KKK=SAVE/PK=SAVE $

    3  FILE     UXV=APPEND $

    4  PARAM    //C,N,NOP/V,Y,CYCID=1 $

    5  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT $

    6  SAVE     LUSET $

    7  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

    8  GP2      GEOM2,EQEXIN/ECT $

    9  CHKPNT   ECT $

   10  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

   11  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

   12  COND     P1,NOPCDB $

   13  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
                JUMPPLOT=-1 $

   14  SAVE     NSIL,JUMPPLOT $

   15  PRTMSG   PLTSETX// $

   16  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

   17  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

   18  COND     P1,JUMPPLOT $


   19  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

   20  SAVE     JUMPPLOT,PLTFLG,PFILE $

   21  PRTMSG   PLOTX1// $

   22  LABEL    P1 $

   23  CHKPNT   PLTPAR,GPSETS,ELSETS $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 14

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


24   GP3       GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $
25   SAVE      NOGRAV $
26   PARAM     //C,N,AND/V,N,NOMGG/V,N,NOGRAV/V,Y,GRDPNT=-1 $
27   CHKPNT    SLT,GPTT $
28   TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,,,/V,N,LUSET/V,N,
               NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $
29   SAVE      NOSIMP,NOGENL,GENEL $
30   PARAM     //C,N,AND/V,N,NOELMT/V,N,NOGENL/V,N,NOSIMP $
31   COND      ERROR4,NOELMT $
32   PURGE     GPST/NOSIMP/0GPST/GENEL $
33   CHKPNT    EST,GPECT,GEI,GPST,0GPST $
34   COND      LBL1,NOSIMP $
35   PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $
36   EMG       EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,,/V,N,NOKGGX/ V,
               N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
               CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
               CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRPSC $
37   SAVE      NOKGGX,NOMGG $
38   CHKPNT    KELM,KDICT,MELM,MDICT $
39   COND      JMPKGG,NOKGGX $
40   EMA       GPECT,KDICT,KELM/KGGX,GPST $
41   CHKPNT    KGGX,GPST $


42   LABEL     JMPKGG $
43   COND      JMPMGG,NOMGG $
44   EMA       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $
45   CHKPNT    MGG $
46   LABEL     JMPMGG $
47   COND      LBL1,GRDPNT $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 14

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


48  COND      ERROR2,NOMGG $
49  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS $
50  OFP       OGPWG,,,,,// $
51  LABEL     LBL1 $
52  EQUIV     KGGX,KGG/NOGENL $
53  CHKPNT    KGG $
54  COND      LBL11A,NOGENL $
55  SMA3      GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
56  CHKPNT    KGG $
57  LABEL     LBL11A $
58  PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
59  GP4       CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N,LUSET/
              V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
              N,REPEAT/V,N,NOSET/V,N,NCL/V,N,NOA/C,Y,SUBID $
60  SAVE      MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NCL,NOA $
61  COND      ERROR3,NCL $
62  PARAM     //C,N,NOT/V,N,REACDATA/V,N,REACT $
63  COND      ERROR6,REACDATA $
64  PURGE     GM/MPCF1/GO,KOO,LOO,PO,UOOV,PUOV/OMIT/PS,KFS,KSS,QG/SINGLE $
65  CHKPNT    GM,GO,KOO,LOO,PO,UOOV,PUOV,PS,KFS,KSS,QG,USET,RG,YS,ASET $
66  GPCYC     GEOM4,EQEXIN,USET/CYCD/V,Y,CTYPE/V,N,NOGO $

67  SAVE      NOGO $
68  CHKPNT    CYCD $
69  COND      ERROR7,NOGO $
70  COND      LBL4,GENEL $
71  GPSP      GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
72  SAVE      NOGPST $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 14

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


73  COND      LBL4,NOGPST $
74  OFP       OGPST,,,,,// $
75  LABEL     LBL4 $
76  EQUIV     KGG,KNN/MPCF1 $
77  CHKPNT    KNN $
78  COND      LBL2,MPCF2 $
79  MCE1      USET,PG/GM $
80  CHKPNT    GM $
81  MCE2      USET,GM,KGG,,,/KNN,,, $
82  CHKPNT    KNN $
83  LABEL     LBL2 $
84  EQUIV     KNN,KFF/SINGLE $
85  CHKPNT    KFF $
86  COND      LBL3,SINGLE $
87  SCE1      USET,KNN,,,/KFF,KFS,KSS,,, $
88  CHKPNT    KFS,KSS,KFF $
89  LABEL     LBL3 $
90  EQUIV     KFF,KAA/OMIT $
91  CHKPNT    KAA $
92  COND      LBL5,OMIT $

93  SMP1      USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $
94  CHKPNT    GO,KAA,KOO,LOO $
95  LABEL     LBL5 $
96  SSG1      SLT,BGPDT,CSTM,SIL,EST,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/V,N,
              LUSET/V,N,NSKIP $
97  CHKPNT    PG $
98  EQUIV     PG,PL/NOSET $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 14

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


 99  CHKPNT   PL $
100  COND     LBL9,NOSET $
101  SSG2     USET,GM,YS,KFS,GO,,PG/,PO,PS,PL $
102  CHKPNT   PO,PS,PL $
103  COND     LBL9,OMIT $
104  SSG3     LOO,KOO,PO,,,/UOOV,,PUOV,/C,N,-1/V,Y,IRES=-1 $
105  CHKPNT   UOOV,RUOV $
106  COND     LBL9,IRES $
107  MATGPR   GPL,USET,SIL,RUOV//C,N,0 $
108  LABEL    LBL9 $
109  EQUIV    PL,PX/CYCID $
110  COND     LBL10,CYCID $
111  CYCT1    PL/PX,GCYCE/V,Y,CTYPE/C,N,FORE/V,Y,NSEGS=-1/V,Y,KMAX=-1/V,Y,
              NLOAD=1/V,N,NOGO $
112  SAVE     KMAX,NOGO $
113  LABEL    LBL10 $
114  CHKPNT   PX $
115  COND     ERROR7,NOGO $
116  PARAM    //C,N,ADD/V,N,KINDEX/C,N,0/C,N,0 $
117  JUMP     LBL11 $                                  Top of DMAP Loop
118  LABEL    LBL11 $

119  CYCT2    CYCD,KAA,,PX,,/KKK,,PK,,/C,N,FORE/V,Y,NSEGS/V,N,KINDEX/V,Y,
              CYCSEQ=-1/V,Y,NLOAD/V,N,NOGO $
120  SAVE     NOGO $
121  CHKPNT   KKK,PK $
122  COND     ERROR7,NOGO $
123  RBMG2    KKK/LKK $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 14

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


124  CHKPNT   LKK $
125  SSG3     LKK,KKK,PK,,,,/UKV,,PUKV,/C,N,-1/V,Y,IRES $
126  CHKPNT   UKV,PUKV $
127  CYCT2    CYCD,,,UKV,PUKV,,,,UXV,PUXV,/C,N,PACK/V,Y,NSEGS/V,N,KINDEX/
              V,Y,CYCSEQ/V,Y,NLOAD/V,N,NOGO $
128  SAVE     NOGO $
129  CHKPNT   UXV,PUXV $
130  COND     ERROR7,NOGO $
131  COND     LBL14,IRES $
132  MATGPR   GPL,USET,SIL,PUXV//C,N,A $
133  LABEL    LBL14 $
134  PARAM    //C,N,ADD/V,N,KINDEX/V,N,KINDEX/C,N,1 $
135  PARAM    //C,N,SUB/V,N,DONE/V,Y,KMAX/V,N,KINDEX $
136  COND     LBL15,DONE $
137  REPT     LBL11,360 $
                                                    Bottom of DMAP Loop
138  JUMP     ERROR1 $
139  LABEL    LBL15 $
140  EQUIV    UXV,ULV/CYCID $
141  COND     LBL16,CYCID $
142  CYCT1    UXV/ULV,CCYCB/V,Y,CTYPE/C,N,BACK/V,Y,NSEGS/V,Y,KMAX/V,Y,NLOAD/
              V,N,NOGO $


143  SAVE     NOGO $
144  COND     ERROR7,NOGO $
145  LABEL    LBL16 $
146  CHKPNT   ULV $
147  SDR1     USET,PG,ULV,UDOV,YS,GO,GM,PS,KFS,KSS,/UGV,PGG,QG/V,N,NSKIP/C,N,
              STATICS $
148  CHKPNT   UGV,PGG,QG $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 14

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


149  COND      NOMPCF,GRDEQ $
150  EQMCK     CASECC,EQEXIN,GPL,BGPDT,SIL,USET,KGG,GM,UGV,PGG,OG,CSTM/  OQM1/
               V,Y,OPT=0/V,Y,GRDEQ/V,N,NSKIP $
151  DEP       OQM1,,,,,,//V,N,CARDNO $
152  SAVE      CARDNO $
153  LABEL     NOMPCF $
154  SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,OG,UGV,EST,,PGG/
               OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,STATICS $
155  PARAM     //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
156  DEP       OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $
157  SAVE      CARDNO $
158  COND      P2,JUMPPLOT $
159  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,,GPECT,OES1/
               PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
160  SAVE      PFILE $
161  PRTMSG    PLOTX2// $
162  LABEL     P2 $
163  JUMP      FINIS $
164  LABEL     ERROP1 $
165  PRTPARM   //C,N,-1/C,N,CYCSTATICS $
166  LABEL     ERROP2 $
167  PRTPARM   //C,N,-2/C,N,CYCSTATICS $

168  LABEL     ERROP3 $
169  PRTPARM   //C,N,-3/C,N,CYCSTATICS $
170  LABEL     ERROP4 $
171  PRTPARM   //C,N,-4/C,N,CYCSTATICS $
172  LABEL     ERROP6 $
173  PRTPARM   //C,N,-6/C,N,CYCSTATICS $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 14

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


174   LABEL     ERROR7 $
175   PRTPARM   //C,N,-7/C,N,CYCSTATICS $
176   LABEL     FINIS $
177   END       $
```

3.15.2 Description of DMAP Operations for Static Analysis Using Cyclic Symmetry

5. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

8. GP2 generates Element Connection Table with internal indices.

12. Go to DMAP No. 22 if no plot output is requested.

13. PLTSET transforms user input into a form used to drive structure plotter.

15. PRTMSG prints error messages associated with structure plotter.

18. Go to DMAP No. 22 if no undeformed structure plots are requested.

19. PLØT generates all requested undeformed structure plots.

21. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

24. GP3 generates Static Loads Table and Grid Point Temperature Table.

28. TA1 generates element tables for use in matrix assembly and stress recovery.

31. Go to DMAP No. 170 and print error message if no elements have been defined.

34. Go to DMAP No. 51 if there are no structural elements.

36. EMG generates structural element stiffness and mass matrix tables and dictionaries for later assembly.

39. Go to DMAP No. 42 if no stiffness matrix is to be assembled.

40. EMA assembles stiffness matrix $[K^{X}_{gg}]$ and Grid Point Singularity Table.

43. Go to DMAP No. 46 if no mass matrix is to be assembled.

44. EMA assembles mass matrix $[M_{gg}]$.

47. Go to DMAP No. 51 if no weight and balance is requested.

48. Go to DMAP No. 166 and print error message if no mass matrix exists.

49. GPWG generates weight and balance information.

50. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

52. Equivalence $[K^{X}_{gg}]$ to $[K_{gg}]$ if no general elements.

54. Go to DMAP No. 57 if no general elements.

55. SMA3 adds general elements to $[K^{X}_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

59. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

61. Go to DMAP No. 168 and print error message if no independent degrees of freedom are defined.

63. Go to DMAP No. 172 and print error message if free-body supports are present.

66. GPCYC prepares segment boundary table (CYCD).

69. Go to DMAP No. 174 and print error message if CYJØIN data is inconsistent.

70. Go to DMAP No. 75 if general elements present.

71. GPSP determines if possible grid point singularities remain.

73. Go to DMAP No. 75 if no grid point singularities remain.

74. ØFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

76. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

78. Go to DMAP No. 83 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

79. MCE1 partitions multipoint constraint equations $[R_g] = [R_m | R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

81. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \tilde{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\tilde{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

84. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

86. Go to DMAP No. 89 if no single-point constraints.

87. SCE1 partitions out single-point constraints.

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right]$$

90. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

92. Go to DMAP No. 95 if no omitted coordinates.

93. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \tilde{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

96. SSG1 generates static load vectors $\{P_g\}$.

98. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

101. SSG2 applies constraints to static load vectors

$$\{P_g\} = \left\{ \begin{array}{c} \bar{P}_n \\ -- \\ P_m \end{array} \right\} , \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\} ,$$

$$\{P_n\} = \left\{ \begin{array}{c} \bar{P}_f \\ -- \\ P_s \end{array} \right\} , \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\} ,$$

$$\{P_f\} = \left\{ \begin{array}{c} \bar{P}_a \\ -- \\ P_o \end{array} \right\} , \qquad \{P_a\} = \{\bar{P}_a\} + [G_o^T]\{P_o\} ,$$

$$\{P_a\} = \left\{ \begin{array}{c} P_\ell \\ -- \\ P_r \end{array} \right\}$$

and calculates determinate forces of reaction $\{q_r\} = -\{P_r\} - [D^T]\{P_\ell\}$.

103. Go to DMAP No. 108 if no omitted coordinates.

104. SSG3 solves for displacements of omitted coordinates (these are not transformed)

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\} ,$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\} ,$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o^o\}} .$$

106. Go to DMAP No. 108 if residual vectors are not to be printed.

107. MATGPR prints the residual vector for omitted coordinates (RUØV).

109. Equivalence $\{P_\ell\}$ to $\{P_x\}$ if symmetric components of loads have been input.

110. Go to DMAP No. 113 if symmetric components of loads have been input.

111. CYCT1 transforms loads on analysis points to symmetric components by the equation

$$\{P_x\} = [G]\{P_\ell\} \quad .$$

115. Go to DMAP No. 174 and print error message if CYCT1 error was found.

117. Go to next DMAP instruction if cold start or modified restart. LBL11 will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

118. Beginning of loop for cyclic index values (KINDEX).

119. CYCT2 transforms matrices and loads from symmetric components to solution set by the equations

$$[K_{kk}] = [G_1^T][K_{aa}][G_1] + [G_2^T][K_{aa}[G_2],$$

where $G_1 = G_c$ (cosine) and $G_2 = G_s$ (sine) for rotational symmetry,

and $G_1 = G_S$ (Symmetric) and $G_2 = G_A$ (Antisymmetric) for dihedral symmetry.

$$\{P_k\} = [G_c^T]\{P_c\} + [G_s^T]\{P_s\} \text{ for rotational symmetry.}$$

$$\{P_k^1\} = [G_S^T]\{P_{cS}\} + [G_A^T]\{P_{sA}\},$$

and $$\{P_k^2\} = [G_A^T]\{P_{cA}\} + [G_S^T]\{P_{sS}\} \text{ for dihedral symmetry.}$$

122. Go to DMAP No. 174 and print error message if CYCT2 error was found.

123. RBMG2 decomposes constrained stiffness matrix for solution set.

$$[K_{kk}] = [L_{kk}][u_{kk}]$$

125. SSG3 solves for displacements of solution set coordinates

$$\{u_k\} = [K_{kk}]^{-1}\{P_k\} \quad ,$$

and calculates residual vector (RUKV) and residual vector error ratio for solution set coordinates

$$\{\delta P_k\} = \{P_k\} - [K_{kk}]\{u_k\} \quad ,$$

$$\varepsilon_k = \frac{\{u_k^T\}\{\delta P_k\}}{\{P_k^T\}\{u_k\}}$$

127. CYCT2 finds symmetric components of displacement from solution set data and appends to output for each KINDEX.

130. Go to DMAP No. 174 and print error message if CYCT2 error was found.

131. Go to DMAP No. 133 if residual vectors are not to be printed.

132. MATGPR prints the residual vector for solution set coordinates (RUXV).

136. Go to DMAP No. 139 if all cyclic index (KINDEX) values are complete.

137. Go to DMAP No. 118 if additional index values are needed.

138. Go to DMAP No. 164 and print error message if number of loops exceeds 360.

140. Equivalence $\{u_x\}$ to $\{u_\ell\}$ if output of symmetric components was requested.

141. Go to DMAP No. 145 if output of symmetric components was requested.

142. CYCT1 transforms displacements from symmetrical components to physical components.

144. Go to DMAP No. 174 and print error message if CYCT1 error was found.

147. SDR1 recovers dependent displacements

$$\{u_o\} = [G_o]\{u_a\} + \{u_o^o\} \quad ,$$

$$\begin{Bmatrix} u_a \\ -- \\ u_o \end{Bmatrix} = \{u_f\} \quad , \qquad \begin{Bmatrix} u_f \\ -- \\ Y_s \end{Bmatrix} = \{u_n\} \quad ,$$

$$\{u_m\} = [G_m]\{u_n\} \quad , \qquad \begin{Bmatrix} u_n \\ -- \\ u_m \end{Bmatrix} = \{u_g\} \quad ,$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\} \quad .$$

149. Go to DMAP No. 153 if no multi-point constraint force balance is requested.

150. EQMCK calculates the force and moment equilibrium check and prepares the multi-point constraint force balance (ØQM1) for output.

151. ØFP formats tables prepared by EQMCK and places them on the system output file for printing.

154. SDR2 calculates element forces (ØEF1) and stresses (ØES1) and prepares load vectors (ØPG1), displacement vectors (ØUGV1) and single-point forces of constraint (ØQG1) for output and translation components of the displacement vector (PUGV1).

156. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

158. Go to DMAP No. 162 if no deformed structure plots are requested.

159. PLØT generates all requested deformed structure and contour plots.

161. PRTMSG prints plotter data, engineering data, and contour data for each deformed plot generated.

163. Go to DMAP No. 171 and make normal exit.

165. STATICS WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 1 - ATTEMPT TØ EXECUTE MØRE THAN 360 LØØPS.

167. STATICS WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 2 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

169. STATICS WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDOM HAVE BEEN DEFINED.

171. STATICS WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

173. STATICS WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 6 - FREE-BØDY SUPPØRTS NØT ALLØWED.

175. STATICS WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 7 - CYCLIC SYMMETRY DATA ERRØR.

3.15.3 Case Control Deck and Parameters for Static Analysis Using Cyclic Symmetry

The following items relate to subcase definition and data selection:

1. A separate group of subcases must be defined for each symmetric segment. For dihedral symmetry, a separate group of subcases are defined for each half. There may be up to 360 subcases corresponding to 1° segments.
2. The different loading conditions are defined within each group of subcases. The loads on each symmetric segment and the selected output requests may be independent. The number of loading cases is specified on the PARAM card NLØAD.
3. The SPC and MPC request must appear above the subcase level and may not be changed.
4. An alternate loading method is to define a separate group of subcases for each harmonic index, k. The parameter CYCIØ is included and the load components for each index are defined directly within each group for the various loading conditions.

The following printed output, for each loading condition and each symmetric segment or index, may be requested for Static Analysis solutions:

1. Displacements and components of static loads and single-point forces of constraint at selected grid points or scalar points.
2. Forces and stresses in selected elements.

The following plotter output may be requested for Static Analysis solutions:

1. Undeformed and deformed plots of the structural model (1 segment).
2. Contour plots of stress and displacement (1 segment).
3. X-Y plot of any component of displacement, static load, or single-point force of constraint for a grid point or scalar point.
4. X-Y plot of any stress or force component for an element.

The following parameters are used in Static Analysis using Cyclic Symmetry:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.
2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in EMA.

3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.

4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPODPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices, rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

5. CTYPE - required - the BCD value of this parameter defines the type of cyclic symmetry as follows:

 (1) RØT - rotational symmetry

 (2) DRL - dihedral symmetry, using right and left halves

 (3) DSA - dihedral symmetry, using symmetric and antisymmetric components

6. NSEGS - required - the integer value of this parameter is the number of identical segments in the structural model.

7. NLØAD - optional - the integer value of this parameter is the number of static loading conditions. The default value is 1.

8. CYCIØ - optional - the integer value of this parameter specifies the form of the input and output data. A value of +1 is used to specify physical segment representation, and a value of -1 for cyclic transform representation. The default value is +1.

9. CYCSEQ - optional - the integer value of this parameter specifies the procedure for sequencing the equations in the solution set. A value of +1 specifies that all cosine terms should be sequenced before all sine terms, and a value of -1 for alternating the cosine and sine terms. The default value is -1.

10. KMAX - optional - the integer value of this parameter specifies the maximum value of the harmonic index. The default value is ALL which is NSEGS/2 for NSEGS even and (NSEGS-1)/2 for NSEGS odd.

11. ØPT - optional in static and normal modes analyses (rigid formats 1, 2, 3, 14, and 15). A positive integer value of this parameter causes both equilibrium and multipoint constraint forces to be calculated for the Case Control output request, MPCFØRCE. A negative integer value of this parameter causes only the equilibrium force balance to be calculated for the output request. The default value is 0 which causes only the multipoint constraint forces to be calculated for the output request.

12. GRDEQ - optional in static and normal modes analyses (rigid formats 1, 2, 3, 14, and 15). A positive integer value of this parameter selects the grid point about which equilibrium will be checked for the Case Control output request, MPCFØRCE. If the integer value is zero, the basic origin is used. Default is -1.

3.16 NORMAL MODES ANALYSIS USING CYCLIC SYMMETRY

3.16.1 DMAP Sequence for Normal Modes Analysis Using Cyclic Symmetry

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 15

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO       ERR=2    NOLIST   NODECK   NOREF    NOOSCAR

    1  BEGIN    NO.15 NORMAL MODES ANALYSIS WITH CYCLIC SYMMETRY - SERIES P $

    2  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT $

    3  SAVE     LUSET $

    4  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

    5  GP2      GEOM2,EQEXIN/ECT $

    6  CHKPNT   ECT $

    7  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

    8  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

    9  COND     P1,NOPCDB $

   10  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
                JUMPPLOT=-1 $

   11  SAVE     NSIL,JUMPPLOT $

   12  PRTMSG   PLTSETX// $

   13  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

   14  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

   15  COND     P1,JUMPPLOT $

   16  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

   17  SAVE     JUMPPLOT,PLTFLG,PFILE $

   18  PRTMSG   PLOTX1//$


   19  LABEL    P1 $

   20  CHKPNT   PLTPAR,GPSETS,ELSETS $

   21  GP3      GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $

   22  CHKPNT   GPTT $

   23  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,,/V,N,LUSET/V,N,
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 15

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

                NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $
24  SAVE        NOGENL,NOSIMP,GENEL $
25  COND        ERROR6,NOSIMP $
26  PURGE       OGPST/GENEL $
27  CHKPNT      EST,GPECT,GEI,OGPST $
28  PARAM       //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $
29  PARAM       //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $
30  (EMG)       EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
                N,NOMGG/C,N, /C,N, /C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/  C,Y,
                CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/C,Y,CPTUBE/ C,Y,
                CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $
31  SAVE        NOKGGX,NOMGG $
32  CHKPNT      KELM,KDICT,MELM,MDICT $
33  COND        JMPKGG,NOKGGX $
34  (EMA)       GPECT,KDICT,KELM/KGGX,GPST $
35  CHKPNT      KGGX,GPST $
36  LABEL       JMPKGG $
37  COND        ERROR1,NOMGG $
38  (EMA)       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $
39  CHKPNT      MGG $
40  COND        LGPWG,GROPNT $
41  (GPWG)      PGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GROPNT=-1/C,Y,WTMASS $

42  OFP         OGPWG,,,,,// $
43  LABEL       LGPWG $
44  EQUIV       KGGX,KGG/NOGENL $
45  CHKPNT      KGG $
46  COND        LBL11,NOGENL $
47  (SMA3)      GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 15

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


48  CHKPNT   KGG $
49  LABEL    LBL11 $
50  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
51  GP4      CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,LUSET/
             V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
             N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
52  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $
53  COND     ERROR3,NOL $
54  PARAM    //C,N,NOT/V,N,REACDATA/V,N,REACT $
55  COND     ERROR4,REACDATA $
56  PURGE    GM/MPCF1/GO/OMIT/KFS,OG/SINGLE $
57  CHKPNT   GM,RG,GO,KFS,OG,USET,ASET $
58  GPCYC    GEOM4,EQEXIN,USET/CYCD/V,Y,CTYPE/V,N,NOGO $
59  SAVE     NOGO $
60  CHKPNT   CYCD $
61  COND     ERROR5,NOGO $
62  COND     LBL4,GENFL $
63  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
64  SAVE     NOGPST $
65  COND     LBL4,NOGPST $
66  OFP      OGPST,,,,,// $

67  LABEL    LBL4 $
68  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1 $
69  CHKPNT   KNN,MNN $
70  COND     LBL2,MPCF2 $
71  MCE1     USET,RG/GM $
72  CHKPNT   GM $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 15

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


73  MCE2      USET,GM,KGG,MGG,,/KNN,MNN,, $
74  CHKPNT    KNN,MNN $
75  LABEL     LBL2 $
76  EQUIV     KNN,KFF/SINGLE/MNN,MFF/SINGLE $
77  CHKPNT    KFF,MFF $
78  COND      LBL3,SINGLE $
79  SCE1      USET,KNN,MNN,,/KFF,KFS,,MFF,, $
80  CHKPNT    KFS,KFF,MFF $
81  LABEL     LBL3 $
82  EQUIV     KFF,KAA/OMIT $
83  EQUIV     MFF,MAA/OMIT $
84  CHKPNT    KAA,MAA $
85  COND      LBL5,OMIT $
86  SMP1      USET,KFF,,,,/GO,KAA,KOO,LOO,,,,, $
87  CHKPNT    GO,KAA $
88  SMP2      USET,GO,MFF/MAA $
89  CHKPNT    MAA $
90  LABEL     LBL5 $
91  DPD       DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,,,,,,,EED,FODYN/V,N,
              LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/   V,
              N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $


92  SAVE      NOEED $
93  COND      ERROR2,NOEED $
94  CHKPNT    EED $
95  CYCT2     CYCD,KAA,MAA,,,,/KKK,MKK,,,,/C,N,FORE/V,Y,NSEGS=-1/V,Y,KINDEX=-1/
              V,Y,CYCSEQ=-1/C,N,1/V,N,NOGO $
96  SAVE      NOGO $
97  CHKPNT    KKK,MKK $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 15

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


 98  COND      ERROR5,NOGO $
 99  READ      KKK,MKK,,,,EED,,CASECC/LAMK,PHIK,MI,OEIGS/C,N,MODES/V,N,NEIGV $
100  SAVE      NEIGV $
101  CHKPNT    LAMK,PHIK,MI,OEIGS $
102  PARAM     //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
103  OFP       OEIGS,,,,,,//V,N,CARDNO $
104  SAVE      CARDNO $
105  COND      FINIS,NEIGV $
106  OFP       LAMK,,,,,,//V,N,CARDNO $
107  SAVE      CARDNO $
108  CYCT2     CYCD,,,,,PHIK,LAMK/,,,PHIA,LAMA/C,N,BACK/V,Y,NSEGS/V,Y,KINDEX/
               V,Y,CYCSEQ/C,N,1/V,N,NOGO $
109  SAVE      NOGO $
110  CHKPNT    PHIA,LAMA $
111  COND      ERROR5,NOGO $
112  SDR1      USET,,PHIA,,,GO,GM,,KFS,,,/PHIG,,QG/C,N,1/C,N,REIG $
113  CHKPNT    PHIG,QG $
114  PARAM     //C,N,SUB/V,N,SCALAR/V,N,SIL/V,N,LUSET $
115  EQUIV     SIL,SIP/SCALAR/BGPDT,BGPDP/SCALAR $
116  CHKPNT    SIP,BGPDP $
117  COND      LBL7,SCALAR $


118  PLTTRAN   BGPDT,SIL/BGPDP,SIP/V,N,LUSET/V,N,LUSEP $
119  SAVE      LUSEP $
120  CHKPNT    BGPDP,SIP $
121  LABEL     LBL7 $
122  COND      NOMPCF,GRDFO $
123  EQMCK     CASECC,EQEXIN,GPL,BGPDT,SIL,USET,KGG,GM,PHIG,LAMA,QG,CSTM/OQMI/
```

```
RIGID FORMAT DMAP LISTING
SERIES P

DISPLACEMENT APPROACH, RIGID FORMAT 15

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

                V,Y,OPT=0/V,Y,GRDEQ/C,N,-1 $
124  OFP        OQM1,,,,,//V,N,CARDNO $
125  SAVE       CARDNO $
126  LABEL      NOMPCF $
127  SDR2       CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDP,LAMA,OG,PHIG,EST,,/,
                OQG1,OPHIG,OES1,OEF1,PPHIG/C,N,REIG $
128  OFP        OPHIG,OQG1,OEF1,OES1,,,//V,N,CARDNO $
129  SAVE       CARDNO $
130  COND       P2,JUMPPLOT $
131  PLOT       PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIP,,PPHIG,GPECT,OES1/
                PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
132  SAVE       PFILE $
133  PRTMSG     PLOTX2// $
134  LABEL      P2 $
135  JUMP       FINIS $
136  LABEL      ERROR1 $
137  PRTPARM    //C,N,-1/C,N,CYCMODES $
138  LABEL      ERROR2 $
139  PRTPARM    //C,N,-2/C,N,CYCMODES $
140  LABEL      ERROR3 $
141  PRTPARM    //C,N,-3/C,N,CYCMODES $
142  LABEL      ERROR4 $
143  PRTPARM    //C,N,-4/C,N,CYCMODES $
144  LABEL      ERROR5 $
145  PRTPARM    //C,N,-5/C,N,CYCMODES $
146  LABEL      ERROR6 $
147  PRTPARM    //C,N,-6/C,N,CYCMODES $
148  LABEL      FINIS $
149  END        $
```

3.16.2 Description of DMAP Operations for Normal Modes Analysis Using Cyclic Symmetry

2. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

5. GP2 generates Element Connection Table with internal indices.

9. Go to DMAP No. 19 if no plot output is requested.

10. PLTSET transforms user input into a form used to drive structure plotter.

12. PRTMSG prints error messages associated with structure plotter.

15. Go to DMAP No. 19 if no undeformed structure plots are requested.

16. PLØT generates all requested undeformed structure plots.

18. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

21. GP3 generates Static Loads Table and Grid Point Temperature Table.

23. TA1 generates element tables for use in matrix assembly and stress recovery.

25. Go to DMAP No. 146 and print error message if no elements have been defined.

30. EMG generates structural element stiffness and mass matrix tables and dictionaries for later assembly.

33. Go to DMAP No. 36 if no stiffness matrix is to be assembled.

34. EMA assembles stiffness matrix $[K^{X}_{gg}]$ and Grid Point Singularity Table.

37. Go to DMAP No. 136 and print error message if no mass matrix exists.

38. EMA assembles mass matrix $[M_{gg}]$.

40. Go to DMAP No. 43 if no weight and balance request.

41. GPWG generates weight and balance information.

42. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

44. Equivalence $[K^{X}_{gg}]$ to $[K_{gg}]$ if no general elements.

46. Go to DMAP No. 49 if no general elements.

47. SMA3 adds general elements to $[K^{X}_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

51. GP4 generates flags defining members of various displacement sets (USET), forms multi-point constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

53. Go to DMAP No. 140 and print error message if no independent degrees of freedom are defined.

55. Go to DMAP No. 142 and print error message if free-body supports are present.

58. GPCYC prepares segment boundary table (CYCD).

61. Go to DMAP No. 144 and print error message if CYJØIN data is inconsistent.

62. Go to DMAP No. 67 if general elements present.

63. GPSP determines if possible grid point singularities remain.

65. Go to DMAP No. 67 if no grid point singularities remain.

66. ØFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

68. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

70. Go to DMAP No. 75 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

71. MCE1 partitions multipoint constraint equations $[R_g] = [R_m | R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

73. MCE2 partitions stiffness matrix

$$[K_{gg}] = \begin{bmatrix} \bar{K}_{nn} & K_{nm} \\ K_{mn} & K_{mm} \end{bmatrix}$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] .$$

76. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

78. Go to DMAP No. 81 if no single-point constraints.

79. SCE1 partitions out single-point constraints

$$[K_{nn}] = \begin{bmatrix} K_{ff} & K_{fs} \\ K_{sf} & K_{ss} \end{bmatrix} \qquad [M_{nn}] = \begin{bmatrix} M_{ff} & M_{fs} \\ M_{sf} & M_{ss} \end{bmatrix}$$

82. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

83. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

85. Go to DMAP No. 90 if no omitted coordinates.

86. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \begin{bmatrix} \bar{K}_{aa} & K_{ao} \\ K_{oa} & K_{oo} \end{bmatrix}$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

88. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \begin{bmatrix} \bar{M}_{aa} & M_{ao} \\ M_{oa} & M_{oo} \end{bmatrix}$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o] .$$

91. DPD extracts Eigenvalue Extraction Data from Dynamics data block.

93. Go to DMAP No. 138 and print error message if no Eigenvalue Extraction Data.

95. CYCT2 transforms matrices from symmetric components to solution set by the equations

$$[K_{kk}] = [G_1^T][K_{aa}][G_1] + [G_2^T][K_{aa}][G_2],$$

and $$[M_{kk}] = [G_1^T][M_{aa}][G_1] + [G_2^T][M_{aa}][G_2],$$

where $G_1 = G_c$ (cosine) and $G_2 = G_s$ (sine) for rotational symmetry,

and $G_1 = G_S$ (Symmetric) and $G_2 = G_A$ (Antisymmetric) for dihedral symmetry.

98. Go to DMAP No. 144 and print error message if CYCT2 error was found.

99. READ extracts real eigenvalues from the equation

$$[K_{kk} - \lambda M_{kk}]\{u_k\} = 0 \quad ,$$

calculates modal mass matrix

$$[m] = [\phi_k^T][M_{kk}][\phi_k]$$

and normalizes eigenvectors according to one of the following user requests:
1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass.

103. ØFP formats the summary of eigenvalue extraction information (ØEIGS) prepared by READ and places it on the system output file for printing.

105. Go to DMAP No. 148 andmake normal exit if no eigenvalues found.

106. ØFP formats eigenvalues (LAMK) prepared by READ and places them on the system output file for printing.

108. CYCT2 finds symmetric components of eigenvectors from solution set eigenvectors.

111. Go to DMAP No. 144 and print error message if CYCT2 error was found.

112. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o]\{\phi_a\} \quad , \qquad \begin{Bmatrix} \phi_a \\ -- \\ \phi_o \end{Bmatrix} = \{\phi_f\} \quad ,$$

$$\begin{Bmatrix} \phi_f \\ -- \\ \phi_s \end{Bmatrix} = \{\phi_n\} \quad , \qquad \{\phi_m\} = [G_m]\{\phi_n\} \quad ,$$

$$\begin{Bmatrix} \phi_n \\ -- \\ \phi_m \end{Bmatrix} = \{\phi_g\}$$

and recovers single-point forces of constraint $\{q_s\} = [K_{fs}]^T\{\phi_f\}$.

115. Equivalence SIL to SIP and BGPDT to BGPDP when one or more geometric grid points exist.

118. PLTTRAN modifies BGPDT and SIL for functional modules SDR2 and PLØT/

122. To to DMAP No. 126 if no multi-point constraint force balance is requested.

123. EQMCK calculates the force and moment equilibrium check and prepares the multi-point constraint force balance (ØQM1) for output.

124. ØFP formats tables prepared by EQMCK and places them on the system output file for printing.

127. SDR2 calculates element forces (ØEF1) and stresses (ØES1) and prepares eigenvectors (ØPHIG) and single-point forces of constraint (ØQG1) for output and translation components of the eigenvectors (PPHIG).

128. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

130. Go to DMAP No. 127 if no deformed structure plots are requested.

131. PLØT generates all requested deformed structure and contour plots.

133. PRTMSG prints plotter data, engineering data, and contour data for each deformed plot generated.

135. Go to DMAP No. 141 and make normal exit.

137. NØRMAL MØDES WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR REAL EIGENVALUE ANALYSIS.

139. NØRMAL MØDES WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

141. NØRMAL MØDES WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

143. NØRMAL MØDES WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 4 - FREE BODY SUPPØRTS NØT ALLØWED.

145. NØRMAL MØDES WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 5 - CYCLIC SYMMETRY DATA ERRØR.

147. NØRMAL MØDES WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 6 - NØ STRUCTURAL ELEMENTS DEFINED.

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY.

3. Multiple subcases are used only to control output requests. A single subcase is sufficient if the same output is desired for all modes. If multiple subcases are present, the output requests will be honored in succession for increasing mode numbers. MØDES may be used to repeat subcases in order to make the same output request for several consecutive modes.

Each NASTRAN run calculates modes for only one symmetry index, k. The following output may be requested for Normal Mode Analysis with Cyclic Symmetry:

1. Eigenvectors along with the associated eigenvalue for each mode.
2. Nonzero components of the single-point forces of constraint for selected modes at selected grid points.
3. Forces and stresses in selected elements for selected modes.
4. Undeformed plot of the structural model and mode shapes for selected modes.
5. Contour plots of stress and displacement for selected modes.

The following parameters are used in Normal Mode Analysis using Cyclic Symmetry:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.
2. WTMASS - optional - the terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.
3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.
4. CTYPE - required - the BCD value of this parameter defines the type of cyclic symmetry as follows:
 (1) RØT - rotational symmetry
 (2) DRL - dihedral symmetry, using right and left halves
 (3) DSA - dihedral symmetry, using symmetric and antisymmetric components

5. NSEGS - required - the integer value of this parameter is the number of identical segments in the structural model.

6. CYCSEQ - optional - the integer value of this parameter specifies the procedure for sequencing the equations in the solution set. A value of +1 specifies that all cosine terms should be sequenced before all sine terms, and a value of -1 for alternating the cosine and sine terms. The default value is -1.

7. KINDEX - required in the normal modes with cyclic symmetry (rigid format 15). The integer value of this parameter specifies a single value of the harmonic index.

8. ØPT - optional in static and normal modes analyses (rigid formats 1, 2, 3, 14, and 15). A positive integer value of this parameter causes both equilibrium and multipoint constraint forces to be calculated for the Case Control output request, MPCFØRCE. A negative integer value of this parameter causes only the equilibrium force balance to be calculated for the output request. The default value of 0 which causes only the multipoint constraint forces to be calculated for the output request.

9. GRDEQ - optional in static and normal modes analyses (rigid formats 1, 2, 3, 14, and 15). A positive integer value of this parameter selects the grid point about which equilibrium will be checked for the Case Control output request, MPCFØRCE. If the integer value is zero, the basic origin is used. Default is -1.

3.16.5 Optional Diagnostic Output for FEER

Special detailed information resulting from requesting DIAG 16 in the Executive Control Deck is the same as described under Normal Modes analysis (see Section 3.4.6).

3.16.6 The APPEND Feature

The APPEND feature can be used for real eigenvalue extraction in Normal Modes Using Cyclic Symmetry. See Section 3.4.7 for details.

3.17 STATIC HEAT TRANSFER ANALYSIS

3.17.1 DMAP Sequence for Static Heat Transfer Analysis

```
RIGID FORMAT DMAP LISTING
SERIES P

HEAT APPROACH, RIGID FORMAT 1

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN    NO.01 STATIC HEAT TRANSFER ANALYSIS - SERIES P $

    2  FILE     HLLL=TAPE $

    3  FILE     HOG=APPEND/HPGG=APPEND/HUGV=APPEND/HGM=SAVE/HKNN=SAVE $

    4  GP1      GEOM1,GEOM2,/GPL,HEQEXIN,GPDT,CSTM,BGPDT,HSIL/V,N,HLUSET/
                N,NOGPDT $

    5  SAVE     HLUSET $

    6  CHKPNT   GPL,HEQEXIN,GPDT,CSTM,BGPDT,HSIL $

    7  GP2      GEOM2,HEQEXIN/ECT $

    8  CHKPNT   ECT $

    9  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

   10  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

   11  COND     HP1,NOPCDB $

   12  PLTSET   PCDB,HEQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,HNSIL/ V,N,
                JUMPPLOT=-1 $

   13  SAVE     HNSIL,JUMPPLOT $

   14  PRTMSG   PLTSETX// $

   15  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

   16  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

   17  COND     HP1,JUMPPLOT $

   18  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,HEQEXIN,HSIL,,ECT,,/PLOTX1/
                V,N,HNSIL/V,N,HLUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $


   19  SAVE     JUMPPLOT,PLTFLG,PFILE $

   20  PRTMSG   PLOTX1// $

   21  LABEL    HP1 $

   22  CHKPNT   PLTPAR,GPSETS,ELSETS $

   23  GP3      GEOM3,HEQEXIN,GEOM2/HSLT,GPTT/V,N,NOGRAV $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

HEAT APPROACH, RIGID FORMAT 1

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


24   CHKPNT    HSLT,GPTT $
25   TA1       ECT,EPT,BGPDT,HSIL,GPTT,CSTM/HEST,,HGPECT,,/V,N,HLUSET/V,N,
               NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $
26   SAVE      NOSIMP $
27   COND      ERROR4,NOSIMP $
28   PURGE     GPST/NOSIMP $
29   CHKPNT    HEST,HGPECT,GPST $
30   COND      HLBL1,NOSIMP $
31   PARAM     //C,N,ADD/V,N,HNOKGG/C,N,1/C,N,0 $
32   EMG       HEST,CSTM,MPT,DIT,GEOM2,/HKELM,HKDICT,,,,/V,N,HNOKGG $
33   SAVE      HNOKGG $
34   CHKPNT    HKELM,HKDICT $
35   COND      HLBL1,HNOKGG $
36   EMA       HGPECT,HKDICT,HKELM/HKGG,GPST $
37   CHKPNT    HKGG,GPST $
38   LABEL     HLBL1 $
39   PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
40   JUMP      HLBL11 $
                                                        Top of DMAP Loop
41   LABEL     HLBL11 $
42   GP4       CASECC,GEOM4,HEQEXIN,GPDT,BGPDT,CSTM/RG,YS,HUSET,HASET/ V,N,
               HLUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/    V,
               N,NSKIP/V,N,HREPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $


43   SAVE      MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,HREPEAT,NOSET,NOL,NOA $
44   COND      ERROR3,NOL $
45   PARAM     //C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT $
46   PURGE     HKRR,HKLR,HOR,HDM/REACT/GM/MPCF1/HGO,HKOO,HLOO,HPO,HUOOV,
               HRUOV/OMIT/HPS,HKFS,HKSS/SINGLE/HOG/NOSR $
47   CHKPNT    HKRR,HKLR,HOR,HDM,GM,HGO,HKOO,HLOO,HPO,HUOOV,HRUOV,HPS,HKFS,
               HKSS,HOG,HUSET,RG,YS,HASET $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

HEAT APPROACH, RIGID FORMAT 1

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


48  (GPSP)     CPL,GPST,HUSET,HSIL/OGPST/V,N,NOGPST $
49  SAVE       NOGPST $
50  COND       HLBL4,NOGPST $
51  OFP        OGPST,,,,,// $
52  LABEL      HLBL4 $
53  EQUIV      HKGG,HKNN/MPCF1 $
54  CHKPNT     HKNN $
55  COND       HLBL2,MPCF2 $
56  (MCE1)     HUSET,RG/GM $
57  CHKPNT     GM $
58  (MCE2)     HUSET,GM,HKGG,,,/HKNN,,, $
59  CHKPNT     HKNN $
60  LABEL      HLBL2 $
61  EQUIV      HKNN,HKFF/SINGLE $
62  CHKPNT     HKFF $
63  COND       HLBL3,SINGLE $
64  (SCE1)     HUSET,HKNN,,,/HKFF,HKFS,HKSS,,, $
65  CHKPNT     HKFS,HKSS,HKFF $
66  LABEL      HLBL3 $
67  EQUIV      HKFF,HKAA/OMIT $

68  CHKPNT     HKAA $
69  COND       HLBL5,OMIT $
70  (SMP1)     HUSET,HKFF,,,/HGO,HKAA,HKOO,HLOO,,,,, $
71  CHKPNT     HGO,HKAA,HKOO,HLOO $
72  LABEL      HLBL5 $
73  EQUIV      HKAA,HKLL/REACT $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

HEAT APPROACH, RIGID FORMAT 1

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


74  CHKPNT    HKLL $
75  COND      HLBL6,REACT $
76  RBMG1     HUSET,HKAA,/HKLL,HKLR,HKRR,,, $
77  CHKPNT    HKLL,HKLR,HKRR $
78  LABEL     HLBL6 $
79  RBMG2     HKLL/HLLL $
80  CHKPNT    HLLL $
81  COND      HLBL7,REACT $
82  RBMG3     HLLL,HKLR,HKRR/HDM $
83  CHKPNT    HDM $
84  LABEL     HLBL7 $
85  SSG1      HSLT,BGPDT,CSTM,HSIL,HEST,MPT,GPTT,EDT,,CASECC,DIT/HPG/V,N,
              HLUSET/V,N,NSKIP $
86  CHKPNT    HPG $
87  EQUIV     HPG,HPL/NOSET $
88  CHKPNT    HPL $
89  COND      HLBL10,NOSET $
90  SSG2      HUSET,GM,YS,HKFS,HGO,HDM,HPG/HOR,HPO,HPS,HPL $
91  CHKPNT    HOR,HPO,HPS,HPL $
92  LABEL     HLBL10 $
93  SSG3      HLLL,HKLL,HPL,HLOO,HKOO,HPO/HULV,HUOOV,HRULV,HRUOV/V,N,OMIT/
              V,Y,IRES=-1/V,N,NSKIP/V,N,EPSI $
94  SAVE      EPSI $
95  CHKPNT    HULV,HUOOV,HRULV,HRUOV $
96  COND      HLBL9,IRES $
97  MATGPR    GPL,HUSET,HSIL,HRULV//C,N,L $
98  MATGPR    GPL,HUSET,HSIL,HRUOV//C,N,O $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

HEAT APPROACH, RIGID FORMAT 1

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


 99  LABEL    HLBL9 $
100  SDR1     HUSET,HPG,HULV,HUOOV,YS,HGO,GM,HPS,HKFS,HKSS,HOR/HUGV,HPGG,HOG/
              V,N,NSKIP/C,N,HSTATICS $
101  CHKPNT   HUGV,HPGG,HOG $
102  COND     HLBL8,HREPEAT $
103  REPT     HLBL11,100 $                          (Bottom of DMAP Loop)
104  JUMP     ERROR1 $
105  PARAM    //C,N,NOT/V,N,HTEST/V,N,HREPEAT $
106  COND     ERROR5,HTEST $
107  LABEL    HLBL8 $
108  CHKPNT   CSTM $
109  SDR2     CASECC,CSTM,MPT,DIT,HEQEXIN,HSIL,GPTT,EDT,BGPDT,,HOG,HUGV,
              HEST,,HPGG/HOPG1,HOOG1,HOUGV1,,HOEF1,HPUGV1/C,N,STATICS $
110  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
111  OFP      HOUGV1,HOPG1,HOOG1,HOEF1,,,//V,N,CARDNO $
112  SAVE     CARDNO $
113  COND     HP2,JUMPPLOT $
114  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,HEQEXIN,HSIL,HPUGV1,,HGPECT,
              /PLOTX2/V,N,HNSIL/V,N,HLUSET/V,N,JUMPPLOT/V,N,PLTFLG/    V,N,
              PFILE $
115  SAVE     PFILE $
116  PRTMSG   PLOTX2// $


117  LABEL    HP2 $
118  JUMP     FINIS $
119  LABEL    ERROR1 $
120  PRTPARM  //C,N,-1/C,N,HSTA $
121  LABEL    ERROR3 $
122  PRTPARM  //C,N,-3/C,N,HSTA $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

HEAT APPROACH, RIGID FORMAT 1

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


123  LABEL    ERROR4 $
124  PRTPARM  //C,N,-4/C,N,HSTA $
125  LABEL    ERROR5 $
126  PRTPARM  //C,N,-5/C,N,HSTA $
127  LABEL    FINIS $
128  END      $
```

3.18 NONLINEAR STATIC HEAT TRANSFER ANALYSIS

3.18.1 DMAP Sequence for Nonlinear Static Heat Transfer Analysis

```
RIGID FORMAT DMAP LISTING
SERIES P

HEAT APPROACH, RIGID FORMAT 3

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN    NO.03 NONLINEAR STATIC HEAT TRANSFER ANALYSIS - SERIES P $
    2  GP1      GEOM1,GEOM2,/GPL,HEQEXIN,GPDT,CSTM,BGPDT,HSIL/V,N,HLUSET/  V,
                N,NOGPDT $
    3  SAVE     HLUSET $
    4  CHKPNT   GPL,HEQEXIN,GPDT,CSTM,BGPDT,HSIL $
    5  GP2      GEOM2,HEQEXIN/ECT $
    6  CHKPNT   ECT $
    7  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
    8  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $
    9  COND     HP1,NOPCDB $
   10  PLTSET   PCDB,HEQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,HNSIL/ V,N,
                JUMPPLOT=-1 $
   11  SAVE     HNSIL,JUMPPLOT $
   12  PRTMSG   PLTSETX// $
   13  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $
   14  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $
   15  COND     HP1,JUMPPLOT $
   16  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,HEQEXIN,HSIL,,ECT,,/PLOTX1/
                V,N,HNSIL/V,N,HLUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
   17  SAVE     JUMPPLOT,PLTFLG,PFILE $
   18  PRTMSG   PLOTX1// $

   19  LABEL    HP1 $
   20  CHKPNT   PLTPAR,GPSETS,ELSETS $
   21  GP3      GEOM3,HEQEXIN,GEOM2/HSLT,GPTT/V,N,NOGRAV $
   22  CHKPNT   HSLT,GPTT $
   23  TA1      ECT,EPT,BGPDT,HSIL,GPTT,CSTM/HEST,,HGPECT,,/V,N,HLUSET/V,N,
```

```
RIGID FORMAT DMAP LISTING
SERIES P

HEAT APPROACH, RIGID FORMAT 3

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

                NOSIMP/C,N,1/V,N,NOGENL/V,N,HYYZ $
24  SAVE        NOSIMP $
25  COND        ERROR2,NOSIMP $
26  CHKPNT      HEST,HGPECT $
27  PARAM       //C,N,ADD/V,N,HNOKGG/C,N,1/C,N,0 $
28  (FMG)       HEST,CSTM,MPT,DIT,GEOM2,/HKELM,HKDICT,,,,/V,N,HNOKGG $
29  SAVE        HNOKGG $
30  CHKPNT      HKELM,HKDICT $
31  COND        JMPKGGX,HNOKGG $
32  (EMA)       HGPECT,HKDICT,HKELM/HKGGX,GPST $
33  CHKPNT      HKGGX,GPST $
34  LABEL       JMPKGGX $
35  (RMG)       HEST,MATPOOL,GPTT,HKGGX/HPGG,HQGE,HKGG/C,Y,TABS/C,Y,SIGMA=0.0/
                V,N,HNLR/V,N,HLUSET $
36  SAVE        HNLR $
37  EQUIV       HKGGX,HKGG/HNLR $
38  PURGE       HQGE,HRGG/HNLR $
39  CHKPNT      HKGG,HQGE,HPGG $
40  (GP4)       CASECC,GEOM4,HEQEXIN,GPDT,BGPDT,CSTM/RG,YS,HUSET,HASET/ V,N,
                HLUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/   V,
                N,NSKIP/V,N,HREPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
41  SAVE        MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,HREPEAT,NOSET,NOL,NOA $

42  COND        ERROR1,NOL $
43  PURGE       GM/MPCF1/HPS,HKFS,HKSS,HKSF,HRSN,HQG/SINGLE $
44  CHKPNT      GM,HPG,HKFS,HKSS,HUSET,RG,HKSF,HRSN,YS $
45  (GPSP)      GPL,GPST,HUSET,HSIL/OGPST/V,N,NOGPST $
46  SAVE        NOGPST $
47  COND        HLBL5,NOGPST $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

HEAT APPROACH, RIGID FORMAT 3

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


48  OFP       OGPST,,,,,// $
49  LABEL     HLBL5 $
50  EQUIV     HKGG,HKNN/MPCF1/HPGG,HRNN/MPCF1 $
51  CHKPNT    HKNN,HRNN $
52  COND      HLBL1,MPCF? $
53  MCE1      HUSET,RG/GM $
54  CHKPNT    GM $
55  MCE2      HUSET,GM,HKGG,HRGG,,/HKNN,HRNN,, $
56  CHKPNT    HKNN,HRNN $
57  LABEL     HLBL1 $
58  EQUIV     HKNN,HKFF/SINGLE/HRNN,HRFN/SINGLE $
59  CHKPNT    HKFF,HRFN $
60  COND      HLBL2,SINGLE $
61  VEC       HUSET/VFS/C,N,N/C,N,F/C,N,S $
62  PARTN     HKNN,VFS,/HKFF,HKSF,HKFS,HKSS $
63  PARTN     HPNN,,VFS/HRFN,HRSN,,/C,N,1 $
64  LABEL     HLBL2 $
65  CHKPNT    HKFS,HKSS,HKFF,HKSF,HRFN,HPSN $
66  DECOMP    HKFF/HLLL,HULL/C,N,0/C,N,0/V,N,MDIAG/V,N,DET/V,N,PWR/V,N,
              KSING $
67  SAVE      KSING $


68  COND      ERROR3,KSING $
69  CHKPNT    HLLL,HULL $
70  SSG1      HSLT,BGPDT,CSTM,HSIL,HEST,MPT,GPTT,EDT,,CASECC,DIT/HPG/V,N,
              HLUSET/V,N,NSKIP $
71  CHKPNT    HPG $
72  EQUIV     HPG,HPF/NOSET $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

HEAT APPROACH, RIGID FORMAT 3

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


73  COND      HLBL3,NOSET $
74  SSG2      HUSET,GM,,HKFS,,,HPG/,,HPS,HPF $
75  LABEL     HLBL3 $
76  CHKPNT    HPF,HPS $
77  SSGHT     HUSET,HSIL,GPTT,GM,HEST,MPT,DIT,HPF,HPS,HKFF,HKFS,HKSF,    HKSS,
              HREN,HRSN,HLLL,HULL/HUGV,HQG,HPULV/V,N,HNNLK=1/V,N,HNLR/    C,Y,
              EPSHT=.001/C,Y,TABS=0.0/C,Y,MAXIT=4/V,Y,IRES/V,N,    MPCF1/V,N,
              SINGLE $
78  CHKPNT    HUGV,HQG,HPULV $
79  COND      HLBL4,IRES $
80  MATGPR    GPL,HUSET,HSIL,HPULV//C,N,F $
81  LABEL     HLBL4 $
82  PLTTRAN   BGPDT,HSIL/BGPDP,HSIP/V,N,HLUSET/V,N,HLUSEP $
83  SAVE      HLUSEP $
84  CHKPNT    BGPDP,HSIP $
85  SDR2      CASECC,CSTM,MPT,DIT,HEQEXIN,HSIL,GPTT,EDT,BGPDT,,HQG,HUGV,HEST,
              ,    HPG/HQPG1,HQQG1,HQUGV1,,HQEF1,HPUGV1/C,N,STATICS $
86  PARAM     //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
87  DEP       HQUGV1,HQPG1,HQQG1,,,,//V,N,CARDNO $
88  SAVE      CARDNO $
89  SDRHT     HSIL,HUSET,HUGV,HQEF1,HSLT,HEST,DIT,HQGE,,/HQEF1X/C,Y,TABS/
              V,N,HNLR $
90  DEP       HQEF1X,,,,,,//V,N,CARDNO $


91  SAVE      CARDNO $
92  COND      HP2,JUMPPLOT $
93  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,HEQEXIN,HSIP,HPUGV1,,HGPECT,
              /PLOTX2/V,N,HNSIL/V,N,HLUSET/V,N,JUMPPLOT/V,N,PLTFLG/    V,N,
              PLTLE $
94  PRTMSG    PLOTX2// $
95  LABEL     HP2 $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

HEAT APPROACH, RIGID FORMAT 3

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


 96  JUMP     FINIS$
 97  LABEL    FRROR1 $
 98  PRTPARM  //C,N,-1/C,N,HNLI $
 99  LABEL    FRROR2 $
100  PRTPARM  //C,N,-2/C,N,HNLI $
101  LABEL    FRROR3 $
102  PRTPARM  //C,N,-3/C,N,HNLI $
103  LABEL    FINIS$
104  END      $
```

3.18.2 Description of DMAP Operations for Nonlinear Static Heat Transfer Analysis

2. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external degree of freedom indices.

5. GP2 generates the Element Connection Table with internal indices.

9. Go to DMAP No. 19 if no plot output is requested.

10. PLTSET transforms user input into a form used to drive structure plotter.

12. PRTMSG prints error messages associated with structure plotter.

15. Go to DMAP No. 19 if no undeformed boundary and structure (heat conduction) element plots are requested.

16. PLØT generates all requested undeformed boundary and heat conduction element plots.

18. PRTMSG prints plotter and engineering data for each generated plot.

21. GP3 generates applied Static (Heat Flux) Load Tables (HSLT) and the Grid Point Temperature Table.

23. TA1 generates element tables for use in matrix assembly, load generation, and heat flux data recovery.

25. Go to DMAP No. 99 and print error message if no elements have been defined.

28. EMG generates element heat conduction matrix tables and dictionaries for later assembly.

31. Go to DMAP No. 34 if no heat conduction matrix is to be assembled.

32. EMA assembles heat conduction matrix $[K^{x}_{gg}]$ and Grid Point Singularity Table.

35. RMG generates the radiation matrix, $[R_{gg}]$, and adds the estimated linear component of radiation to the heat conduction matrix. The element radiation flux matrix, $[Q_{ge}]$, is also generated for use in recovery data for the HBDY elements.

37. Equivalence $[K^{x}_{gg}]$ to $[K_{gg}]$ if no linear component of radiation.

40. GP4 generates flags defining member of various displacement sets (HUSET) and forms multi-point constraint equations $[R_g]\{u_g\} = \{0\}$.

42. Go to DMAP No. 97 if no independent degrees of freedom are defined.

45. GPSP determines if possible grid point singularities remain. These may be extraneous in a radiation problem, since some points may transfer heat through radiation only.

47. Go to DMAP No. 49 if no Grid Point Singularity Table.

48. ØFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

50. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[R_{gg}]$ to $[R_{nn}]$ if no multi-point constraints exist.

52. Go to DMAP No. 57 if no multi-point constraints exist.

53. MCE1 partitions the multi-point constraint equation matrix $[R_g] = [R_m : R_n]$ and solves for the multi-point constraint transformation matrix

$$[G_m] = -[R_n]^{-1}[R_n].$$

3.19 TRANSIENT HEAT TRANSFER ANALYSIS

3.19.1 DMAP Sequence for Transient Heat Transfer Analysis

```
RIGID FORMAT DMAP LISTING
SERIES P

HEAT APPROACH, RIGID FORMAT 9

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN    NO.09 TRANSIENT HEAT TRANSFER ANALYSIS - SERIES P $

    2  FILE     HKGGX=TAPE/HKGG=TAPE $

    3  GP1      GEOM1,GEOM2,/GPL,HEQEXIN,GPDT,CSTM,BGPDT,HSIL/V,N,HLUSET/
                N,NOGPDT/V,N,ALWAYS=-1 $

    4  SAVE     HLUSET,NOGPDT $

    5  PURGE    HUSET,GM,HGO,HKAA,HBAA,HPSO,HKFS,HQP,HEST/NOGPDT $

    6  CHKPNT   GPL,HEQEXIN,GPDT,CSTM,BGPDT,HSIL,HUSET,GM,HGO,HKAA,HBAA, +
                HKFS,HQP,HEST $

    7  COND     HLBL5,NOGPDT $

    8  GP2      GEOM2,HEQEXIN/ECT $

    9  CHKPNT   ECT $

   10  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

   11  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

   12  COND     HP1,NOPCDB $

   13  PLTSET   PCDB,HEQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,HNSIL/
                JUMPPLOT=-1 $

   14  SAVE     HNSIL,JUMPPLOT $

   15  PRTMSG   PLTSETX// $

   16  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

   17  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

   18  COND     HP1,JUMPPLOT$


   19  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,HEQEXIN,HSIL,,ECT,,/PLOTX1/
                V,N,HNSIL/V,N,HLUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

   20  SAVE     JUMPPLOT,PLTFLG,PFILE $

   21  PRTMSG   PLOTX1// $

   22  LABEL    HP1 $
```

```
RIGID FORMAT DMAP LISTING
SERIES 9

HEAT APPROACH, RIGID FORMAT 9

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


23  CHKPNT   PLTPAR,GPSETS,ELSETS $
24  GP3      GEOM3,HEQEXIN,GEOM2/HSLT,GPTT/C,N,1 $
25  CHKPNT   GPTT,HSLT $
26  TA1      ECT,EPT,BGPDT,HSIL,GPTT,CSTM/HEST,,HGPECT,,/V,N,HLUSET/V,N,
             NOSIMP=-1/C,N,1/C,N,123/C,N,123 $
27  SAVE     NOSIMP $
28  CHKPNT   HEST,HGPECT $
29  COND     HLBL1,NOSIMP $
 0  PARAM    //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $
 1  PARAM    //C,N,ADD/V,N,NOBGG/C,N,1/C,N,0 $
 2  EMG      HEST,CSTM,MPT,DIT,GEOM2,/HKELM,HKDICT,,,HBELM,HBDICT/V,N
             NOKGGX/C,N,/V,N,NOBGG $
 3  SAVE     NOKGGX,NOBGG $
 4  CHKPNT   HKELM,HKDICT,HBELM,HBDICT $
 5  COND     JMPKGGX,NOKGGX $
 6  EMA      HGPECT,HKDICT,HKELM/HKGGX,GPST $
 7  CHKPNT   HKGGX,GPST $
 8  LABEL    JMPKGGX $
 9  COND     JMPHBGG,NOBGG $
 0  EMA      HGPECT,HBDICT,HBELM/HBGG, $
 1  CHKPNT   HBGG $


 2  LABEL    JMPHBGG $
 3  PURGE    HBNN,HBEE,HBAA,HBGG/NOBGG $
 4  CHKPNT   HBGG,HBNN,HBEE,HBAA $
 5  LABEL    HLBL1 $
 6  EMG      HEST,MATPOOL,GPTT,HKGGX/HBGG,HOGE,HKGG/C,Y,TABS/C,Y,SIGMA=
             V,N,HNLP/V,N,HLUSET $
 7  SAVE     HNLP $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

HEAT APPROACH, RIGID FORMAT 9

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


48  EQUIV     HKGGX,HKGG/HNLR $

49  PURGE     HRGG,HRNN,HREE,HRAA,HRDD/HNLR $

50  CHKPNT    HPGG,HRNN,HREE,HRAA,HRDD,HKGG,HQGE $

51  GP4       CASECC,GEOM4,HEQEXIN,GPDT,BGPDT,CSTM/PG,,HUSET,ASET/V,N,HLUSET/
              V,N,MPCF1=-1/V,N,MPCF2=-1/V,N,SINGLE=-1/V,N,OMIT=-1/ V,N,REACT=
              -1/C,N,0/C,N,123/V,N,NOSET=-1/V,N,NOL/V,N,NOA=-1 $

52  SAVE      MPCF1,SINGLE,OMIT,NOSET,REACT,MPCF2,NOL,NOA $

53  PURGE     GM,GMD/MPCF1/HGO,HGOD/OMIT/HKFS,HPSO,HQP/SINGLE $

54  CHKPNT    GM,PG,HGO,HKFS,HQP,HUSET,GMD,HGOD,HPSO $

55  COND      HLBL2,NOSIMP $

56  GPSP      GPL,GPST,HUSET,HSIL/OGPST/V,N,NOGPST $

57  SAVE      NOGPST $

58  COND      HLBL2,NOGPST $

59  OFP       OGPST,,,,,// $

60  LABEL     HLBL2 $

61  EQUIV     HKGG,HKNN/MPCF1/HPGG,HRNN/MPCF1/HBGG,HBNN/MPCF1 $

62  CHKPNT    HKNN,HRNN,HBNN $

63  COND      HLBL3,MPCF1 $

64  MCF1      HUSET,PG/GM $

65  CHKPNT    GM $

66  MCF2      HUSET,GM,HKGG,HRGG,HBGG,/HKNN,HRNN,HBNN, $


67  CHKPNT    HKNN,HRNN,HBNN $

68  LABEL     HLBL3 $

69  EQUIV     HKNN,HKFF/SINGLE/HRNN,HRFF/SINGLE/HBNN,HBFF/SINGLE $

70  CHKPNT    HKFF,HRFF,HBFF $

71  COND      HLBL4,SINGLE $

72  SCF1      HUSET,HKNN,HRNN,HBNN,/HKFF,HKFS,,HRFF,HBFF, $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

HEAT APPROACH, RIGID FORMAT 9

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


 73  CHKPNT   HKFS,HKFF,HRFF,HBFF $
 74  LABEL    HLBL4 $
 75  EQUIV    HKFF,HKAA/OMIT $
 76  EQUIV    HRFF,HRAA/OMIT $
 77  EQUIV    HBFF,HBAA/OMIT $
 78  CHKPNT   HKAA,HRAA,HBAA $
 79  COND     HLBL5,OMIT $
 80  (SMP1)   HUSET,HKFF,,,/HGO,HKAA,HKOO,HLOO,,,,, $
 81  CHKPNT   HGO,HKAA $
 82  COND     HLBLR,HNLR $
 83  (SMP2)   HUSET,HGO,HRFF/HRAA $
 84  CHKPNT   HRAA $
 85  LABEL    HLBLR $
 86  COND     HLBL5,NOBGG $
 87  (SMP2)   HUSET,HGO,HBFF/HBAA $
 88  CHKPNT   HBAA $
 89  LABEL    HLBL5 $
 90  (DPD)    DYNAMICS,GPL,HSIL,HUSET/GPLD,HSILD,HUSETD,TFPOOL,HDLT,,,HNLFT,
              HTRL,,HEQDYN/V,N,HLUSET/V,N,HLUSETD/C,N,123 /V,N,NODLT/   C,N,
              123/C,N,123/V,N,NONLFT/V,N,NOTRL/C,N,123/C,N, /V,N,NOUE $
 91  SAVE     HLUSETD,NODLT,NONLFT,NOTRL,NOUE $


 92  COND     FPROP1,NOTRL $
 93  EQUIV    HGO,HGOO/NOUE/GM,GMO/NOUE $
 94  PURGE    HPPO,HPSO,HPOO,HPOT/NODLT $
 95  CHKPNT   HUSETD,HEQDYN,TFPOOL,HDLT,HTRL,HGOO,GMO,HNLFT,HSILD,GPLD,HPPO,
              HPSO,HPOO,HPOT $
 96  (MTRXIN) CASECC,MATPOOL,HEQDYN,,TFPOOL/HK2PP,,HB2PP/V,N,HLUSETD/  V,N,
              NOK2PP/C,N,123/V,N,NOB2PP $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

HEAT APPROACH, RIGID FORMAT 9

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


 97  SAVE     NOK2PP,NOB2PP $

 98  PARAM    //C,N,AND/V,N,KDEKA/V,N,NOUE/V,N,NOK2PP $

 99  PURGE    HK2DD/NOK2PP/HB2DD/NOB2PP $

100  EQUIV    HKAA,HKDD/KDEKA/HB2PP,HB2DD/NOA/HK2PP,HK2DD/NOA/HRAA,HPDD/
              NOUE $

101  CHKPNT   HK2PP,HB2PP,HK2DD,HB2DD,HKDD,HRDD $

102  COND     HLBL6,NOGPDT $

103  (GKAD)   HUSETD,GM,HGO,HKAA,HPAA,HRAA,,HK2PP,,HB2PP/HKDD,HBDD,  HRDD,
              GMD,HGOD,HK2DD,HM2DD,HB2DD/C,N,TRANRESP/C,N,DISP/C,N,  DIRECT/
              C,Y,G=0.0/C,Y,W3=0.0/C,Y,W4=0.0/V,N,NOK2PP/C,N,-1/   V,N,
              NOB2PP/V,N,MPCF1/V,N,SINGLE/V,N,OMIT/V,N,NOUE/  C,N,-1/V,N,
              NOBGG/V,N,NOSIMP/C,N,-1 $

104  LABEL    HLBL6 $

105  EQUIV    HK2DD,HKDD/NOSIMP/HB2DD,HBDD/NOGPDT $

106  CHKPNT   HKDD,HBDD,HRDD,GMD,HGOD $

107  (TRLG)   CASECC,HUSETD,HDLT,HSLT,BGPDT,HSIL,CSTM,HTPL,DIT,GMD,HGOD,,
              HEST,/HPPD,HPSD,HPDD,HPDT,,HTOL/V,N,NOSET/V,N,PDEPDD $

108  SAVE     PDEPDD,NOSET $

109  EQUIV    HPPD,HPDD/NOSET $

110  EQUIV    HPDD,HPDT/PDEPDD $

111  CHKPNT   HPPD,HPDD,HPSD,HTOL,HPDT $

112  (TRHT)   CASECC,HUSETD,HNLFT,DIT,GPTT,HKDD,HBDD,HRDD,HPDT,HTPL/ HUDVT,
              HPNLD/C,Y,BETA=.55/C,Y,TABS=0.0/V,N,HNLR/C,Y,RADLIN=-1 $

113  CHKPNT   HUDVT,HPNLD $


114  (VDR)    CASECC,HEQDYN,HUSETD,HUDVT,HTOL,XYCDB,HPNLD/HOUDV1,HOPNL1/  C,
              N,TRANRESP/C,N,DIRECT/C,N,0/V,N,NOD/V,N,NOP/C,N,0 $

115  SAVE     NOD,NOP $

116  CHKPNT   HOUDV1,HOPNL1 $

117  COND     HLBL7,NOD $

118  (SDR3)   HOUDV1,HOPNL1,,,,/HOUDV2,HOPNL2,,,, $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

HEAT APPROACH, RIGID FORMAT 9

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


119  PARAM     //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
120  DEP       HOUDV2,HOPNL2,,,,,//V,N,CARDNO $
121  SAVE      CARDNO $
122  CHKPNT    HOPNL2,HOUDV2 $
126  LABEL     HLBL7 $
127  PARAM     //C,N,AND/V,N,PJUMP/V,N,NOP/V,N,JUMPPLOT $
128  COND      HLBL9,PJUMP $
129  EQUIV     HUDVT,HUPV/NOA $
130  COND      HLBL8,NOA $
131  SDR1      HUSETD,,HUDVT,,,HGOD,GMD,HPSD,HKFS,,/HUPV,,HOP/C,N,1/C,N,
               TRANSNT $
132  LABEL     HLBL9 $
133  CHKPNT    HUPV,HOP $
134  PLTTRAN   BGPDT,HSIL/BGPDP,HSIP/V,N,HLUSET/V,N,HLUSEP $
135  SAVE      HLUSEP $
136  SDR2      CASECC,CSTM,MPT,DIT,HEQDYN,HSILD,,,BGPDP,HTOL,HOP,HUPV,HEST,
               XYCDB,HPPD/HOPP1,HOOP1,HOUPV1,,HOEF1,HPUGV/C,N,TRANPESP $
137  SDPHT     HSILD,HUSETD,HUPV,HOEF1,HSLT,HEST,DIT,HOGE,HOLT,/HOEF1X/C,Y,
               TABS/V,N,HNLP $
138  EQUIV     HOEF1X,HOEF1/ALWAYS $
139  SDR3      HOPP1,HOOP1,HOUPV1,,HOEF1,/HOPP2,HOOP2,HOUPV2,,HOEF2, $
140  CHKPNT    HOPP2,HOOP2,HOUPV2,HOEF2 $


141  DEP       HOPP2,HOOP2,HOUPV2,HOEF2,,,//V,N,CARDNO $
142  SAVE      CARDNO $
143  COND      HP2,JUMPPLOT $
144  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,HEQEXIN,HSIP,,HPUGV, HGPECT,/
               PLOTX2/V,N,HNSIL/V,N,HLUSEP/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
145  SAVE      PFILE $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

HEAT APPROACH, RIGID FORMAT 9

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


146  PRTMSG    PLOTX2// $

147  LABEL     HP2 $

148  XYTRAN    XYCDB,HOPP2,HOQP2,HOUPV2,,HOEF2/HXYPLTT/C,N,TRAN/C,N,PSET/V,N,
               PFILE/V,N,CARDNO $

149  SAVE      PFILE,CARDNO $

150  XYPLOT    HXYPLTT// $

151  LABEL     HLBL9 $

152  JUMP      FINIS $

153  LABEL     ERROR1 $

154  PRTPARM   //C,N,-1/C,N,HTRD $

155  LABEL     FINIS$

156  END
```

3.19.2 Description of DMAP Operations for Transient Heat Transfer Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external degree of freedom indices.

7. Go to DMAP No. 89 if no grid point definition table.

8. GP2 generates the Element Connection Table with internal indices.

12. Go to DMAP No. 22 if no plot output is requested.

13. PLTSET transforms user input into a form used to drive the structure plotter.

15. PRTMSG prints error messages associated with the structure plotter.

18. Go to DMAP No. 22 if no undeformed boundary and structure (heat conduction) element plots are requested.

19. PLØT generates all requested undeformed boundary and heat conduction element plots.

21. PRTMSG prints plotter data and engineering data for each generated plot.

24. GP3 generates applied Static (Heat Flux) Load Tables (HSLT) and the Grid Point Temperature Table.

26. TA1 generates element tables for use in matrix assembly, load generation, and data recovery.

29. Go to DMAP No. 45 if no heat conduction or boundary elements exist.

32. EMG generates element heat conduction and capacitance matrix tables and dictionaries for later assembly.

35. Go to DMAP No. 38 if no heat conduction matrix is to be assembled.

36. EMA assembles heat conduction matrix $[K^{x}_{gg}]$ and Grid Point Singularity Table.

39. Go to DMAP No. 42 if no heat capacitance matrix is to be assembled.

40. EMA assembles heat capacitance matrix $[B_{gg}]$.

46. RMG generates the radiation matrix, $[R_{gg}]$, and adds the estimated linear component of radiation to the conductivity matrix. The element-radiation flux matrix, $[Q_{ge}]$, is also generated for use in data recovery.

48. Equivalence the linear heat transfer matrix, $[K_{gg}]$, to the heat conduction matrix if no radiation exists.

51. GP4 generates flags defining members of various displacement sets (HUSET) and forms the multi-point constraint equations, $[R_g]\{u_g\} = 0$.

55. Go to DMAP No. 60 if no simple elements exist.

56. GPSP determines if possible grid point singularities remain. These may be extraneous in a radiation problem, since some points may transfer heat through radiation only.

58. Go to DMAP No. 60 if no Grid Point Singularity Table.

59. ØFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

61. Equivalence $[K_{gg}]$ to $[K_{nn}]$, $[R_{gg}]$ to $[R_{nn}]$, and $[B_{gg}]$ to $[B_{nn}]$ if no multi-point constraints exist.

3.20 MODAL FLUTTER ANALYSIS

3.20.1 DMAP Sequence for Modal Flutter Analysis

```
RIGID FORMAT DMAP LISTING
SERIES P

AERO APPROACH, RIGID FORMAT 10

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN    AERO NO. 10 MODAL FLUTTER ANALYSIS SERIES P $

    2  FILE     PHIHL=APPEND/AJJL=APPEND/FSAVE=APPEND/CASEYY=APPEND/CLAMAL
                APPEND/ OVG=APPEND/QHHL=APPEND/SKJ=APPEND/QHJL=APPEND/QKHL
                APPEND/ $

    3  (GP1)    GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N
                NOGPDT $

    4  SAVE     LUSET,NOGPDT $

    5  COND     ERROR1,NOGPDT $

    6  (GP2)    GEOM2,EQEXIN/ECT $

    7  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,JUMPPLOT $

    8  (GP3)    GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $

    9  (TA1)    ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,,/V,N,LUSET/V,N,
                NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

   10  SAVE     NOGENL,NOSIMP,GENEL $

   11  COND     ERROR1,NOSIMP $

   12  PARAM    //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

   13  PARAM    //C,N,ADD/V,N,NOMGG /C,N,1/C,N,0 $

   14  (EMG)    EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
                N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/  C,Y,
                CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/C,Y,CPTUBE/ C,Y,
                CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

   15  SAVE     NOKGGX,NOMGG $

   16  COND     JMPKGGX,NOKGGX $


   17  (EMA)    GPECT,KDICT,KELM/KGGX,GPST $

   18  CHKPNT   KGGX,GPST $

   19  LABEL    JMPKGGX $

   20  COND     ERROR1,NOMGG $

   21  (EMA)    GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

AERO APPROACH, RIGID FORMAT 10

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


22  CHKPNT   MGG $
23  COND     LGPWG,GRDPNT $
24  GPWG     BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $
25  OFP      OGPWG,,,,,//V,N,CARDNO $
26  LABEL    LGPWG $
27  EQUIV    KGGX,KGG/NOGENL $
28  CHKPNT   KGG $
29  COND     LBL11,NOGENL $
30  SMA3     GEI,/KGGY/V,N,LUSET/V,N,NOGENL/C,N,-1 $
31  CHKPNT   KGGY $
32  ADD      KGGX,KGGY/KGG $
33  CHKPNT   KGG $
34  LABEL    LBL11 $
35  GP4      CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,,USET,ASET/V,N,LUSET/V,
             N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/C,N,0/REPEAT/V,
             N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
36  SAVE     MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2, REPEAT,NOL,NOA $
37  CHKPNT   RG,USET $
38  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
39  SAVE     NOGPST $
40  COND     LBL4,NOGPST $

41  OFP      OGPST,,,,,//V,N,CARDNO $
42  LABEL    LBL4 $
43  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1 $
44  COND     LBL2,MPCF1 $
45  MCE1     USET,RG/GM $
46  MCE2     USET,GM,KGG,MGG,,/KNN,MNN,, $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

AERO APPROACH, RIGID FORMAT 10

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


47  CHKPNT   KNN,MNN $
48  LABEL    LBL2 $
49  CHKPNT   GM $
50  EQUIV    KNN,KFF/SINGLE/MNN,MFF/SINGLE $
51  COND     LBL3,SINGLE $
52  SCE1     USET,KNN,MNN,,/KFF,KFS,,MFF,, $
53  LABEL    LBL3 $
54  CHKPNT   KFS,KFF,MFF $
55  EQUIV    KFF,KAA/OMIT/ MFF,MAA/OMIT $
56  CHKPNT   KAA,MAA $
57  PURGE    GO/OMIT $
58  CHKPNT   GO $
59  COND     LBL5,OMIT $
60  PARAM    //C,N,PREC/V,N,PREC $
61  VEC      USET/V/C,N,F/C,N,O/C,N,A $
62  PARTN    KFF,V,/KOO,,KOA,KAAB $
63  CHKPNT   KOO,KOA,KAAB $
64  DECOMP   KOO/LOO,UOO/C,N,1/C,N,0/V,N,MIND/V,N,DET/V,N,NDET/V,N,SING $
65  SAVE     MIND,DET,NDET,SING $
66  COND     LSING,SING $

67  JUMP     CONT $
68  LABEL    LSING $
69  PRTPARM  //C,N,0 $
70  LABEL    CONT $
71  CHKPNT   LOO,UOO $
72  FBS      LOO,UOO,KOA/GO/C,N,1/C,N,-1/V,N,PREC/V,N,PREC $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

AERO APPROACH, RIGID FORMAT 10

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


73  CHKPNT   GO $
74  MPYAD    KOA,GO,KAAB/KAA/C,N,1/C,N,1/C,N,1/V,N,PREC $
75  CHKPNT   KAA $
76  SMP2     USET,GO,MFF/MAA $
77  CHKPNT   MAA $
78  LABEL    LBL5 $
79  COND     LBL6,REACT $
80  RBMG1    USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $
81  CHKPNT   KLL,KLR,KRR,MLL,MLR,MRR $
82  RBMG2    KLL/LLL/ $
83  CHKPNT   LLL $
84  RBMG3    LLL,KLR,KRR/DM $
85  CHKPNT   DM $
86  RBMG4    DM,MLL,MLR,MRR/MR $
87  CHKPNT   MR $
88  LABEL    LBL6 $
89  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,,,,,,EED,EQDYN/V,
             N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/V,
             N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,123/V,N,NOUE $
90  SAVE     LUSETD,NOUE,NOEED $
91  COND     ERROR2,NOEED $


92  EQUIV    GO,GOD/NOUE/GM,GMD/NOUE $
93  READ     KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N,
             NEIGV $
94  SAVE     NEIGV $
95  CHKPNT   LAMA,PHIA,MI,OEIGS $
96  OFP      OEIGS,,,,,//V,N,CARDNO $
97  SAVE     CARDNO $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

AERO APPROACH, RIGID FORMAT 10

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


 98  COND     ERROR4,NEIGV $
 99  OFP      LAMA,,,,,//V,N,CARDNO $
100  SAVE     CARDNO $
101  MTRXIN   CASECC,MATPOOL,EQDYN,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N,
              NOK2PP/V,N,NOM2PP/V,N,NOB2PP $
102  SAVE     NOK2PP,NOM2PP,NOB2PP $
103  EQUIV    M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA $
104  CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD $
105  GKAD     USETD,GM,GO,,,,,K2PP,M2PP,B2PP/,,,GMD,GOD,K2DD,M2DD,B2DD/C,N,
              CMPLEV/C,N,DISP/C,N,MODAL/C,N,0.0/C,N,0.0/C,N,0.0/V,N,NOK2PP/V,
              N,NOM2PP/V,N,NOB2PP/ V,N,MPCF1/V,N,SINGLE/V,N,OMIT/V,N,NOUE/C,
              N,-1/C,N,-1/ C,N,-1/C,N,-1 $
106  CHKPNT   K2DD,M2DD,B2DD,GOD,GMD $
107  GKAM     USETD,PHIA,,LAMA,DIT,M2DD,B2DD,K2DD,CASECC/MHH,BHH,KHH,PHIDH/V,
              N,NOUE/C,Y,LMODES=0/C,Y,LFREQ=0./C,Y,HFREQ=0./V,N,  NOM2PP/V,N,
              NOB2PP/V,N,NOK2PP/V,N,NONCUP/V,N,FMODE/C,Y,KDAMP $
108  SAVE     NONCUP,FMODE $
109  CHKPNT   MHH,BHH,KHH,PHIDH $
110  APD      EDT,EQDYN,ECT,BGPDT,SILD,USETD,CSTM,GPLD/EQAERO,ECTA,BGPA,SILA,
              USETA,SPLINE,AERO,ACPT,FLIST,CSTMA,GPLA,SILGA/V,N,NK/V,N,NJ/V,
              N,LUSETA/V,N,BOV $
111  SAVE     NK,NJ,LUSETA,BOV $
112  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,1 $
113  COND     SKPPLT,JUMPPLOT $


114  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,0/C,N,1 $
115  PLTSET   PCDB,EQAERO,ECTA/PLTSETA,PLTPARA,GPSETSA,ELSETSA/V,N,NSIL1/V,N,
              JUMPPLOT $
116  SAVE     NSIL1,JUMPPLOT $
117  PRTMSG   PLTSETA // $
118  COND     SKPPLT,JUMPPLOT $
119  PLOT     PLTPARA,GPSETSA,ELSETSA,CASECC,BGPA,EQAERO, ,,,,/PLOTX2/V,N,
```

```
RIGID FORMAT DMAP LISTING
SERIES P

AERO APPROACH, RIGID FORMAT 10

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

                NSIL1/V,N,LUSETA/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
120  SAVE       PFILE,JUMPPLOT,PLTFLG $
121  PRTMSG     PLOTX2 // $
122  LABEL      SKPPLT $
123  COND       ERROR2,NOEED $
124  GI         SPLINE,USET ,CSTMA,BGPA,SIL , ,GM,GO/GTKA/V,N,NK/V,N,LUSET $
125  CHKPNT     GTKA $
126  PARAM      //C,N,ADD/V,N,DESTRY/C,N,0/C,N,1/ $
127  AMG        AERO,ACPT/AJJL,SKJ,D1JK,D2JK/V,N,NK/V,N,NJ/V,N,DESTRY/ $
128  SAVE       DESTRY $
129  CHKPNT     AJJL,SKJ,D1JK,D2JK $
130  COND       NODJE,NODJE $
131  INPUTT2    /D1JE,D2JE,,,/C,Y,PU=0/C,Y,P2=11/C,Y,P3=XXXXXXXX $
132  LABEL      NODJE $
133  PARAM      //C,N,ADD/V,N,XQHHL/C,N,1/C,N,0 $
134  AMP        AJJL,SKJ,D1JK,D2JK,GTKA,PHIDH,D1JE,D2JE,USETD,AERO/QHHL,QKHL,
                QHJL/V,N,NOUE/V,N,XQHHL/V,Y,GUSTAERO=+1 $
135  SAVE       XQHHL $
136  CHKPNT     QHHL,QKHL,QHJL $
137  PARAM      //C,N,MPY/V,N,NOP/C,N,-1/C,N,1 $
138  PARAM      //C,N,MPY/V,N,NOP/C,N,1/C,N,1 $

139  PARAM      //C,N,MPY/V,N,NOH/C,N,0/C,N,1 $
140  PARAM      //C,N,MPY/V,N,FLOOP/V,Y,NODJE=-1/C,N,0 $
141  JUMP       LOOPTOP $
                                                    Top of DMAP Loop
142  LABEL      LOOPTOP $
143  FA1        KHH,BHH,MHH,QHHL,CASECC,FLIST/FSAVE,KXHH,BXHH,MXHH/V,N,FLOOP/
                V,N,TSTART/V,N,NOCEAD $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

AERO APPROACH, RIGID FORMAT 10

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


144  SAVE     FLOOP,TSTART,NOCEAD $
145  CHKPNT   FSAVE,KXHH,BXHH,MXHH $
146  EQUIV    KXHH,PHIH/NOCEAD/BXHH,CLAMA/NOCEAD/KXHH,PHIHL/NOCEAD/BXHH,
              CLAMAL/NOCEAD/CASECC,CASEYY/NOCEAD $
147  CHKPNT   PHIH,CLAMA,PHIHL,CLAMAL,CASEYY $
148  COND     VDR,NOCEAD $
149  CEAD     KXHH,BXHH,MXHH,EED,CASECC/PHIH,CLAMA,OCEIGS,/V,N,EIGVS $
150  SAVE     EIGVS $
151  COND     LBLZAP,EIGVS $
152  LABEL    VDR $
153  COND     LBL16,NOH $
154  VDR      CASECC,EQDYN ,USETD,PHIH,CLAMA,,/OPHIH,/C,N,CEIGEN/C,N,MODAL/C,
              N,   123/V,N,NOH /V,N,NOP/V,N,FMODE $
155  SAVE     NOH,NOP $
156  COND     LBL16,NOH $
157  OFP      OPHIH,,,,,//V,N,CARDNO $
158  SAVE     CARDNO $
159  LABEL    LBL16 $
160  FA2      PHIH,CLAMA ,FSAVE/PHIHL,CLAMAL,CASEYY,OVG/V,N,TSTART/   C,Y,
              VREF=1.0/C,Y,PRINT=YES $
161  SAVE     TSTART $
162  CHKPNT   PHIHL,CLAMAL,CASEYY,OVG $


163  COND     CONTINUE,TSTART $
164  LABEL    LBLZAP $
165  COND     CONTINUE,FLOOP $
166  REPT     LOOPTOP,100 $
167  JUMP     ERROR3 $                    Bottom of DMAP Loop
168  LABEL    CONTINUE $
```

```
RIGID FORMAT OMAP LISTING
SERIES P

AERO APPROACH, RIGID FORMAT 10

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


169  CHKPNT    OVG $
170  PARAML    XYCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOXYCDB $
171  COND      NOXYOUT,NOXYCDB $
172  XYTRAN    XYCDB,OVG,,,,/XYPLTCE/C,N,VG/C,N,PSET/V,N,PFILE/V,N,CARDNO/  V,
               N,NOXYPL $
173  SAVE      PFILE,CARDNO,NOXYPL $
174  COND      NOXYOUT,NOXYPL $
175  XYPLOT    XYPLTCE// $
176  LABEL     NOXYOUT $
177  PARAM     //C,N,AND/V,N,PJUMP/V,N,NOP=-1/V,N,JUMPPLOT $
178  COND      FINIS,PJUMP $
179  MODACC    CASEYY,CLAMAL,PHIHL,,,/CLAMAL1,CPHIH1,CASEZZ,,/C,N,CEIGN $
180  ADR       CPHIH1,CASEZZ,QKHL,CLAMAL1,SPLINE,SILA,USETA/PKF/V,N,BOV/   C,
               Y,MACH = 0.0/C,N,FLUTTER $
181  DDR1      CPHIH1,PHIDH/CPHID $
182  CHKPNT    CPHID $
183  EQUIV     CPHID ,CPHIP/NOA $
184  COND      LBL14,NOA $
185  SDR1      USETD,,CPHID ,,,GOD,GMD,,KFS,,/CPHIP,,QPC/C,N,1 /C,N,DYNAMICS $
186  LABEL     LBL14 $
187  CHKPNT    CPHIP,QPC $

188  EQUIV     CPHID ,CPHIA/NOUE $
189  COND      LBLNOE,NOUE $
190  VEC       USETA/RP/C,N,D/C,N,A/C,N,E $
191  PARTN     CPHID ,,RP/CPHIA,,,/C,N,1/C,N,3 $
192  LABEL     LBLNOE $
193  MPYAD     GTKA,CPHIA,/CPHIK/C,N,1/C,N,1/C,N,0/V,N,PREC $
```

RIGID FORMAT DMAP LISTING
SERIES P

AERO APPROACH, RIGID FORMAT 10

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
194  UMERGE    USETA,CPHIP,/CPHIPS/C,N,PS/C,N,P/C,N,SA $
195  UMERGE    USETA,CPHIPS,CPHIK/CPHIPA/C,N,PA/C,N,PS/C,N,K $
196  CHKPNT    CPHIPA $
197  UMERGE    USETA,QPC,/QPAC/C,N,PA/C,N,P/C,N,K $
198  CHKPNT    QPAC $
199  SDR2      CASEZZ,CSTMA,MPT,DIT,EQAERO,SILA,,,BGPA,CLAMAL1,QPAC,CPHIPA,
               EST,,/,OQPAC1,OCPHIPA,OESC1,OEFC1,PCPHIPA/C,N,CEIGN $
200  CHKPNT    PCPHIPA $
201  OFP       OCPHIPA,OQPAC1,OESC1,OEFC1,,//V,N,CARDNO $
202  COND      FINIS,JUMPPLOT $
203  PLOT      PLTPAR4,GPSETSA,ELSETSA,CASEZZ,BGPA,EQAERO,SILGA,,PCPHIPA, ,
               /PLOTX3/V,N,NSIL1/V,N,LUSETA/V,N,JUMPPLOT/V,N,PLTFLG/V,N,
               PFILE $
204  PRTMSG    PLOTX3// $
205  JUMP      FINIS $
206  LABEL     ERROR3 $
207  PRTPARM   //C,N,-3/C,N,FLUTTER $
208  LABEL     ERROR2 $
209  PRTPARM   //C,N,-2/C,N,FLUTTER $
210  LABEL     ERROR1 $
211  PRTPARM   //C,N,-1/C,N,FLUTTER $
212  LABEL     ERROR4 $
213  PRTPARM   //C,N,-4/C,N,FLUTTER $
214  LABEL     FINIS $
215  END       $
```

3.20.2 Description of DMAP Operations for Modal Flutter Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

5. Go to DMAP No. 210 and print error message if no grid points are present.

6. GP2 generates Element Connection Table with internal indices.

8. GP3 generates Static Loads Table and Grid Point Temperature Table.

9. TA1 generates element tables for use in matrix assembly and stress recovery.

11. Go to DMAP No. 210 and print error message if no elements have been defined.

14. EMG generates structural element stiffness and mass matrix tables and dictionaries for later assembly.

16. Go to DMAP No. 19 if no stiffness matrix is to be assembled.

17. EMA assembles stiffness matrix $[K^{x}_{gg}]$ and Grid Point Singularity Table.

20. Go to DMAP No. 210 and print error message if no mass matrix exists.

21. EMA assembles mass matrix $[M_{gg}]$.

23. Go to DMAP No. 26 if no weight and balance request.

24. GPWG generates weight and balance information.

25. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

27. Equivalence $[K^{x}_{gg}]$ to $[K_{gg}]$ if no general elements.

29. Go to DMAP No. 34 if no general elements.

30. SMA3 forms the general element stiffness matrix $[K^{y}_{gg}]$.

32. ADD combines the structural stiffness matrix $[K^{x}_{gg}]$ with the general element stiffness matrix $[K^{y}_{gg}]$ to obtain the stiffness matrix $[K_{gg}]$.

35. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

38. GPSP determines if possible grid point singularities remain.

40. Go to DMAP No. 42 if no grid point singularities remain.

41. ØFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

43. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

44. Go to DMAP No. 48 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

45. MCE1 partitions multipoint constraint equations $[R_g] = [R_m : R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

46. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \begin{bmatrix} \bar{K}_{nn} & K_{nm} \\ K_{mn} & K_{mm} \end{bmatrix} \quad \text{and} \quad [M_{gg}] = \begin{bmatrix} \bar{M}_{nn} & M_{nm} \\ M_{mn} & M_{mm} \end{bmatrix}$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \text{ and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m] \ .$$

50. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

51. Go to DMAP No. 53 if no single-point constraints.

52. SCE1 partitions out single-point constraints

$$[K_{nn}] = \begin{bmatrix} K_{ff} & K_{fs} \\ K_{sf} & K_{ss} \end{bmatrix} \quad \text{and} \quad [M_{nn}] = \begin{bmatrix} M_{ff} & M_{fs} \\ M_{sf} & M_{ss} \end{bmatrix}$$

55. Equivalence $[K_{ff}]$ to $[K_{aa}]$ and $[M_{ff}]$ to $[M_{aa}]$ if no omitted degrees of freedom.

59. Go to DMAP No. 78 if no omitted coordinates.

61. VEC generates an f-size partitioning vector (V) for the o- and a-sets.

$$\{u_f\} \rightarrow \{u_o\} + \{u_a\}$$

62. PARTN partitions constrained stiffness matrix using V.

$$[K_{ff}] = \begin{bmatrix} \bar{K}_{aa} & K_{ao} \\ K_{oa} & K_{oo} \end{bmatrix}$$

64. DECØMP decomposes $[K_{oo}]$ into upper and lower triangular factors $[U_{oo}]$ and $[L_{oo}]$.

66. To to DMAP No. 63 if $[K_{oo}]$ is singular.

67. Go to DMAP No. 70 if $[K_{oo}]$ is not singular.

69. PRTPARM prints all values in the parameter table when $[K_{oo}]$ is singular.

72. FBS solves for the transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$.

74. MPYAD performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY.

76. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \begin{bmatrix} \bar{M}_{aa} & M_{ao} \\ M_{oa} & M_{oo} \end{bmatrix}$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oo}][G_o] + [G_o^T][M_{oa}] .$$

79. Go to DMAP No. 88 if no free-body supports.

80. RBMG1 partitions out free-body supports

$$[K_{aa}] = \begin{bmatrix} K_{\ell\ell} & K_{\ell r} \\ K_{r\ell} & K_{rr} \end{bmatrix} \quad \text{and} \quad [M_{aa}] = \begin{bmatrix} M_{\ell\ell} & M_{\ell r} \\ M_{r\ell} & M_{rr} \end{bmatrix}$$

82. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

84. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}]$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D] ,$$

and calculates and outputs rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||}$$

86. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

89. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers (GPLD), including extra points introduced for dynamic analysis (SILD), and prepares Transfer Function Pool (TFPØØL), and Eigenvalue Extraction Data (EED).

91. Go to DMAP No. 208 and print error message if no Eigenvalue Extraction Data.

92. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

93. READ extracts real eigenvalues and vectors from the equation

$$[K_{aa} - \lambda M_{aa}]\{\phi_a\} = 0 ,$$

calculates rigid body modes by finding a matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized and computes rigid body eigenvectors

$$[\phi_{ao}] = \begin{bmatrix} D\,\phi_{ro} \\ \phi_{ro} \end{bmatrix} ,$$

calculates modal mass matrix

$$[m] = [\phi_z^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:
1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass

96. ØFP formats the summary of eigenvalue extraction information (ØEIGS) prepared by READ and places it on the system output file for printing.

98. Go to DMAP No. 212 and print error message if no eigenvalues are found.

99. ØFP formats the eigenvalues (LAMA) prepared by READ and places them on the system output file for printing.

101. MTRXIN selects the direct input matrices $[K^2_{pp}]$, $[M^2_{pp}]$, and $[B^2_{pp}]$.

103. Equivalence $[M^2_{pp}]$ to $[M^2_{dd}]$, $[B^2_{pp}]$ to $[B^2_{dd}]$ and $[K^2_{pp}]$ to $[K^2_{dd}]$ if no constraints applied.

105. GKAD applies constraints to direct input matrices $[K^2_{pp}]$, $[M^2_{pp}]$, and $[B^2_{pp}]$, forming $[K^2_{dd}]$, $[M^2_{dd}]$, and $[B^2_{dd}]$ and forms $[G_{md}]$ and $[G_{od}]$.

107. GKAM selects eigenvectors to form $[\phi_{dh}]$ and assembles stiffness, mass and damping matrices in modal coordinates:

$$[K_{hh}] = \begin{bmatrix} k_i & 0 \\ 0 & 0 \end{bmatrix} + [\phi^T_{dh}][K^2_{dd}][\phi_{dh}] \quad ,$$

$$[M_{hh}] = \begin{bmatrix} m_i & 0 \\ 0 & 0 \end{bmatrix} + [\phi^T_{dh}][M^2_{dd}][\phi_{dh}] \quad ,$$

$$[B_{hh}] = \begin{bmatrix} b_i & 0 \\ 0 & 0 \end{bmatrix} + [\phi^T_{dh}][B^2_{dd}][\phi_{dh}] \quad .$$

where

KDAMP = 1 (default)	KDAMP = -1
m_i = modal masses	m_i = modal masses
$b_i = m_i\ 2\pi\ f_i\ g(f_i)$	$b_i = 0$
$k_i = m_i\ 4\pi^2\ f_i$	$k_i = (1+ig(f_i))\ 4\pi^2\ f_i^2 m_i$

110. APD processes the aerodynamic data cards from EDT. It adds the k points and the SA points to USETD making USETA. EQAERØ, ECTA, BGPA, CSTMA, GPLA, and SILA are updated to reflect the new elements. AERØ and ACPT reflect the aerodynamic parameters. SILGA is a special SIL for plotting.

113. Go to DMAP No. 122 if no plot output is requested.

115. PLTSET transforms user input into a form used to drive structure plotter.

117. PRTMSG prints error messages associated with structure plotter.

118. Go to DMAP No. 122 if no undeformed aerodynamic or structural element plots are requested.

119. PLØT generates all requested undeformed aerodynamic and structural element plots.

121. PRTMSG prints plotter data and engineering data for each undeformed aerodynamic and structural plot generated.

123. Go to DMAP No. 208 and print error message if no Eigenvalue Extraction Data.

124. GI forms a transformation matrix $[G_{ka}^T]$ which interpolates between aerodynamic (k) and structural (a) degrees of freedom.

127. AMG forms the aerodynamic matrix list $[A_{jj}]$, the area matrix $[S_{kj}]$, and the downwash coefficients $[D_{jk}^1]$ and $[D_{jk}^2]$.

130. Go to DMAP No. 132 if no user-supplied downwash coefficients.

131. INPUTT2 provides the user-supplied downwash factors due to extra points ($[D_{je}^1]$m $[D_{je}^2]$). PARAM NØDJE must be set to enter these matrices. The downwash w_j on box j due to the motion of an extra point, u_e, is given by

$$\{w_j\} = [D_{je}^1 + ikD_{je}^2]\{u_e\} .$$

134. AMP computes the aerodynamic matrix list related to the modal coordinates as follows:

$$[\phi_{dh}] = \begin{bmatrix} \phi_{ai} & \phi_{ae} \\ \hline \phi_{ei} & \phi_{ee} \end{bmatrix} \qquad [G_{ki}] = [G_{ka}^T]^T[\phi_{ai}]$$

$$[D_{jh}^1] \Leftarrow [D_{ji}^1 \mid D_{je}^1] \qquad [D_{ji}^1] = [D_{jk}^1]^T[G_{ki}]$$

$$[D_{jh}^2] \Leftarrow [D_{ji}^2 \mid D_{je}^2] \qquad [D_{ji}^2] = [D_{jk}^2]^T[G_{ki}]$$

For each (m,k) pair:

$$[D_{jh}] = [D_{jh}^1] + ik[D_{jh}^2]$$

For each group:

$$[Q_{jh}] = [A_{jj}^T]^{-1}_{\text{group}} [D_{jh}]_{\text{group}}$$

$$[Q_{kh}] = [S_{kj}][Q_{jh}]$$

$$[Q_{ih}] = [G_{ki}]^T[Q_{kh}]$$

$$[Q_{hh}] \Leftarrow \begin{bmatrix} Q_{ih} \\ \hline Q_{eh} \end{bmatrix}$$

140. PARAM initializes the flutter loop counter (FLØØP) to zero.

141. Go to next DMAP instruction if cold start or modified restart. LØØPTØP will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

142. Beginning of loop for flutter.

143. FA1 computes the total aerodynamic mass matrix $[M_{hh}^x]$, the total aerodynamic stiffness matrix $[K_{hh}^x]$ and the total aerodynamic damping matrix $[B_{hh}^x]$ as well as a looping table FSAVE. For

the K-method

$$M^x_{hh} = (k^2/b^2)M_{hh} + (\rho/2)\, Q_{hh} \quad ,$$
$$K^x_{hh} = K_{hh} \quad ,$$
$$B^x_{hh} = 0 \quad .$$

147. Equivalences set up for KE- and PK-methods.

148. Go to DMAP No. 152 for KE- and PK-methods.

149. CEAD extracts complex eigenvalues from the equation

$$[M^x_{hh}p^2 + B^x_{hh}p + K^x_{hh}]\{\phi_h\} = 0$$

and normalizes eigenvectors to unit magnitude of largest component.

151. Go to DMAP No. 164 if no complex eigenvalues found.

153. Go to DMAP No. 159 if no output request for the extra points introduced for dynamic analysis or modal coordinates.

154. VDR prepares eigenvectors (ØPHIH) for output, using only the extra points introduced for dynamic analysis and modal coordinates.

156. Go to DMAP No. 159 if no output request for the extra points introduced for dynamic analysis or modal coordinates.

157. ØFP formats tables of eigenvectors for extra points introduced for dynamic analysis and modal coordinates prepared by VDR and places them on the system output file for printing.

160. FA2 appends eigenvectors to PHIHL, eigenvalues to CLAMAL, Case Control to CASEYY, and V-g plot data to ØVG.

163. Go to DMAP No. 168 if there is insufficient time for another flutter loop.

165. Go to DMAP No. 168 if flutter loop complete.

166. Go to DMAP No. 141 for additional aerodynamic configuration triplet values.

167. Go to DMAP No. 206 and print error message if number of flutter loops exceeds 100.

171. Go to DMAP No. 176 if no X-Y plot request.

172. XYTRAN prepares the input for requested V-g plotting.

175. XYPLØT prepares requested V-g plots.

178. Go to DMAP No. 214 if no output requests involve dependent degrees of freedom or forces and stresses and make normal exit.

179. MØDACC selects a list of eigenvalues and vectors whose imaginary parts (velocity in input units) are close to a user input list.

180. ADR builds a matrix of aerodynamic forces for each aerodynamic point and prints requested aerodynamic forces for selected elements.

181. DDR1 transforms the complex eigenvectors from modal to physical coordinates

$$\{\phi^c_d\} = \{\phi_{dh}\}\{\phi_h\} \quad .$$

183. Equivalence $\{\phi^c_d\}$ to $\{\phi^c_p\}$ if no constraints applied.

184. Go to DMAP No. 186 if no constraints applied.

185. SDR1 recovers dependent components of eigenvectors

$$\{\phi_o^c\} = [G_o^d]\{\phi_d^c\} \quad , \qquad \begin{Bmatrix} \phi_d \\ \hline \phi_o \end{Bmatrix} = \{\phi_f^c + \phi_e^c\} \quad ,$$

$$\begin{Bmatrix} \phi_f^c + \phi_e^c \\ \hline \phi_s^c \end{Bmatrix} = \{\phi_n^c + \phi_e^c\} \quad , \qquad \{\phi_m^c\} = [G_m^d]\{\phi_n^c + \phi_e^c\} \quad ,$$

$$\begin{Bmatrix} \phi_f^c + \phi_e^c \\ \hline \phi_m^c \end{Bmatrix} = \{\phi_p^c\}$$

and recovers single-point forces of constraint $\{q_s\} = [K_{fs}^T]\{\phi_f\}$, $\begin{Bmatrix} 0 \\ \hline q_s \end{Bmatrix} = \{Q_p^c\}$.

188. Equivalence $\{\phi_d^c\}$ to $\{\phi_a^c\}$ if no extra points introduced for dynamic analysis.

189. Go to DMAP No. 192 if no extra points present.

190. VEC generates a d-size partitioning vector (RP) for the a- and e-sets.

$$\{u_d\} \rightarrow \{u_a\} + \{u_e\}$$

191. PARTN performs partition of $\{\phi_d^c\}$ using RP.

$$\{\phi_d^c\} \Rightarrow \begin{Bmatrix} \phi_a^c \\ \hline \phi_e^c \end{Bmatrix}$$

193. MPYAD recovers the displacements at the aerodynamic points (k).

$$\{\phi_k^c\} = [G_{ka}^T]^T\{\phi_a^c\} \ .$$

194. UMERGE is used to expand $\{\phi_p^c\}$ to the ps-set.

195. UMERGE places $\{\phi_k^c\}$ in its proper place in the displacement vector

$$\{\phi_{pa}^c\} \Leftarrow \begin{Bmatrix} \phi_{ps}^c \\ \hline \phi_k^c \end{Bmatrix}$$

197. UMERGE is used to expand $\{Q_p^c\}$ to the pa-set.

199. SDR2 calculates element forces (ØEFC1) and stresses (ØESC1) and prepares eigenvectors (ØCPHIPA) and single-point forces of constraint (ØQPAC1) for output and PCPHIPA for deformed plotting.

201. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

202. Go to DMAP No. 214 if no deformed aerodynamic or structural element plots are requested and make normal exit.

203. PLØT prepares all deformed aerodynamic and structural element plots.

204. PRTMSG prints plotter data and engineering data for each deformed plot generated.

205. Go to DMAP No. 214 and make normal exit.

207. MØDAL FLUTTER ANALYSIS ERRØR MESSAGE NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

209. MØDAL FLUTTER ANALYSIS ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

211. MØDAL FLUTTER ANALYSIS ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

213. MØDAL FLUTTER ANALYSIS ERRØR MESSAGE NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

3.20.3 Output for Modal Flutter Analysis

The Real Eigenvalue Summary Table and the Real Eigenvalue Analysis Summary, as described under Normal Mode Analysis, are automatically printed. All real eigenvalues are included even though all may not be used in the modal formulation.

The complex eigenvalues are included in the Flutter Summary and are printed for each aerodynamic loop.

The grid point singularities from the structural model are also output.

A Flutter Summary for each value of the configuration parameters is printed out unless PRINT=NØ. This shows Mach number, density, reduced frequency, velocity, damping, and frequency for each complex eigenvalue.

V-g and V-f plots may be requested by the XYØUT control cards by specifying the curve type as VG. The "points" are loop numbers and the "components" are G or F.

Printed output of the following types, sorted by complex eigenvalue root number (SØRT1) and (m, k, ρ) may be requested for all complex eigenvalues kept, as either real and imaginary parts or magnitude and phase angle (0° - 360° lead). (Eigenvectors are not available for the KE-method).

1. The eigenvector for a list of PHYSICAL and AERØDYNAMIC points (grid points, extra points, and aerodynamic points) or SØLUTIØN points (modal coordinates and extra points).
2. Nonzero components of the single-point forces of constraint for a list of PHYSICAL points.
3. Complex stresses and forces in selected elements.

The ØFREQUENCY case control card can select a subset of the complex eigenvectors for data recovery. In addition, undeformed and deformed shapes may be requested. Undeformed shapes may include only structural or structural and aerodynamic elements.

The eigenvectors used in the modal formulation may be obtained for the analysis points by using the ALTER feature to print the matrix of eigenvectors following the execution of READ. The eigenvectors for all points in the model may be obtained by running the problem initially on the Normal Mode Analysis Rigid Format or by making a modified restart using the Normal Mode Analysis Rigid Format.

3.20.4 Case Control Deck and Parameters for Modal Flutter Analysis

1. Only one subcase is allowed.
2. Desired direct input matrices for stiffness $[K^2_{pp}]$, mass $[M^2_{pp}]$, and damping $[B^2_{pp}]$ must be

2405 739 · 956

selected via the keywords K2PP, M2PP, or B2PP.

3. CMETHØD must be used to select an EIGC card from the Bulk Data Deck. (K method only).
4. FMETHØD must be used to select a FLUTTER card from the Bulk Data Deck.
5. METHØD must be used to select an EIGR card that exists in the Bulk Data Deck.
6. SDAMPING must be used to select a TABDMP1 table if structural damping is desired.

The following user parameters are used in Modal Flutter Analysis.

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.
2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.
3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - These parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.
4. LFREQ and HFREQ - required unless LMØDES is used. The real values of these parameters give the frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation. The default values for each parameter are 0.0.
5. LMØDES - required unless LFREQ and HFREQ are used. The integer value of this parameter is the number of lowest modes to be used in the modal formulation. The default value is 0.
6. NØDJE - optional in modal flutter analysis. A positive integer of this parameter indicates that user supplied downwash matrices due to extra points are to be read from tape via the INPUTT2 module in the rigid format. The default value is -1, when not needed.
7. P1, P2 and P3 - required in modal flutter analysis when using NØDJE parameter. See Section 5.3.2 for tape operation parameters required by INPUTT2 module. The defaults for P1, P2 and P3 are 0,11, and XXXXXXXX, respectively.
8. VREF - optional in modal flutter analysis. Velocities are divided by the real value of this parameter to convert units or to compute flutter indices. The default value is 1.0.

9. PRINT - optional in modal flutter analysis. The BCD value, NØ, of this parameter will suppress the automatic printing of the flutter summary for the K method. The default value is YES.
10. GUSTAERØ - optional in modal flutter analysis. If gust loads are to be computed (on restart for instance), set value to +1. The default is -1 for no gust loads.
11. KDAMP - optional in modal flutter analysis. If set to +1, modal damping is put into a complex stiffness matrix as structural damping (+1 recommended for K and KE methods). The default value is -1 when not needed.
12. MACH - optional in modal flutter analysis. The real value of this parameter selects the closest Mach numbers to be used to compute aerodynamic matrices. The default is 0.0.

3.20.5 The APPEND Feature

The APPEND feature can be used for real eigenvalue extraction in Modal Flutter Analysis. See Section 3.4.7 for details.

3.21 MODAL AEROELASTIC RESPONSE

3.21.1 DMAP Sequence for Modal Aeroelastic Response

```
RIGID FORMAT DMAP LISTING
SERIES P

AERO APPROACH, RIGID FORMAT 11

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

  1  BEGIN    AERO NO. 11 MODAL AEROELASTIC RESPONSE SERIES P $

  2  FILE     AJJL=APPEND/QHHL=APPEND/QKHL=APPEND/QHJL=APPEND/SKJ=APPEND $

  3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
               NOGPDT $

  4  SAVE     LUSET,NOGPDT $

  5  COND     ERROR1,NOGPDT $

  6  GP2      GEOM2,EQEXIN/ECT $

  7  PARAML   PCDB//C,N,PRES/V,Y,NODJE=-1///V,N,JUMPPLOT $

  8  PARAML   XYCDB//C,N,PRES////V,N,NOXYCDB $

  9  PARAM    //C,N,MPY/V,N,NOP/C,N,1/C,N,1 $

 10  PARAM    //C,N,MPY/V,N,NOH/C,N,1/C,N,1 $

 11  GP3      GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $

 12  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,,/V,N,LUSET/V,N,
               NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

 13  SAVE     NOGENL,NOSIMP,GENEL $

 14  COND     ERROR1,NOSIMP $

 15  PARAM    //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

 16  PARAM    //C,N,ADD/V,N,NOMGG /C,N,1/C,N,0 $

 17  EMG      EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
               N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/  C,Y,
               CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/C,Y,CPTUBE/ C,Y,
               CPODPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $


 18  SAVE     NOKGGX,NOMGG $

 19  COND     JMPKGGX,NOKGGX $

 20  EMA      GPECT,KDICT,KELM/KGGX,GPST $

 21  CHKPNT   KGGX,GPST $

 22  LABEL    JMPKGGX $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

AERO APPROACH, RIGID FORMAT 11

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


23  COND      ERROR1,NOMGG $
24  EMA       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $
25  CHKPNT    MGG $
26  COND      LGPWG,GRDPNT $
27  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $
28  OFP       OGPWG,,,,,,//V,N,CARDNO $
29  LABEL     LGPWG $
30  EQUIV     KGGX,KGG/NOGENL $
31  CHKPNT    KGG $
32  COND      LBL11,NOGENL $
33  SMA3      GEI,/KGGY/V,N,LUSET/V,N,NOGENL/C,N,-1 $
34  CHKPNT    KGGY $
35  ADD       KGGX,KGGY/KGG $
36  CHKPNT    KGG $
37  LABEL     LBL11 $
38  GP4       CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,,USET,ASET/V,N,LUSET/V,
              N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/C,N,0/V,N,
              REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
39  SAVE      MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2, REPEAT,NOL,NOA $
40  CHKPNT    RG,USET $
41  GPSP      GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $


42  SAVE      NOGPST $
43  COND      LBL4,NOGPST $
44  OFP       OGPST,,,,,,//V,N,CARDNO $
45  LABEL     LBL4 $
46  EQUIV     KGG,KNN/MPCF1/MGG,MNN/MPCF1 $
47  COND      LBL2,MPCF1 $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

AERO APPROACH, RIGID FORMAT 11

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


48 (MCE1)   USET,RG/GM $
49 (MCE2)   USET,GM,KGG,MGG,,/KNN,MNN,, $
50  CHKPNT  KNN,MNN $
51  LABEL   LBL2 $
52  CHKPNT  GM $
53  EQUIV   KNN,KFF/SINGLE/MNN,MFF/SINGLE $
54  COND    LBL3,SINGLE $
55 (SCE1)   USET,KNN,MNN,,/KFF,KFS,,MFF,, $
56  LABEL   LBL3 $
57  CHKPNT  KFF,KFS,MFF $
58  EQUIV   KFF,KAA/OMIT/ MFF,MAA/OMIT $
59  CHKPNT  KAA,MAA $
60  PURGE   GO/OMIT $
61  CHKPNT  GO $
62  COND    LBL5,OMIT $
63  PARAM   //C,N,PREC/V,N,PREC $
64  VEC     USET/V/C,N,F/C,N,O/C,N,A $
65  PARTN   KFF,V,/KOO,,KOA,KAAB $
66  CHKPNT  KOO,KOA,KAAB $
67  DECOMP  KOO/LOO,UOO/C,N,1/C,N,O/V,N,MIND/V,N,DET/V,N,NDET/V,N,SING $

68  SAVE    MIND,DET,NDET,SING $
69  COND    LSING,SING $
70  JUMP    CONT1 $
71  LABEL   LSING $
72  PRTPARM //C,N,O $
73  LABEL   CONT1 $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

AERO APPROACH, RIGID FORMAT 11

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


74  CHKPNT    LOO,UOO $
75  FBS       LOO,UOO,KOA/GO/C,N,1/C,N,-1/V,N,PREC/V,N,PREC $
76  CHKPNT    GO $
77  MPYAD     KOA,GO,KAAB/KAA/C,N,1/C,N,1/C,N,1/V,N,PREC $
78  CHKPNT    KAA $
79  SMP2      USET,GO,MFF/MAA $
80  CHKPNT    MAA $
81  LABEL     LBL5 $
82  COND      LBL6,REACT $
83  RBMG1     USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $
84  CHKPNT    KLL,KLR,KRR,MLL,MLR,MRR $
85  RBMG2     KLL/LLL/ $
86  CHKPNT    LLL $
87  RBMG3     LLL,KLR,KRR/DM $
88  CHKPNT    DM $
89  RBMG4     DM,MLL,MLR,MRR/MR $
90  CHKPNT    MR $
91  LABEL     LBL6 $
92  DPD       DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,DLT,PSDL,FRL,,TRL,
              EED,EQDYN/V,N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/
              V,N,NOFRL/V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,123/V,N,NOUE $


93  SAVE      LUSETD,NOUE,NOEED,NOPSDL $
94  COND      ERROR2,NOEED $
95  EQUIV     GO,GOD/NOUE/GM,GMD/NOUE $
96  READ      KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N,
              NEIGV $
97  SAVE      NEIGV $
98  CHKPNT    LAMA,PHIA,MI,OEIGS $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

AERO APPROACH, RIGID FORMAT 11

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


 99  OFP       OEIGS,,,,,//V,N,CARDNO $
100  SAVE      CARDNO $
101  COND      ERROR4,NEIGV $
102  OFP       LAMA,,,,,//V,N,CARDNO $
103  SAVE      CARDNO $
104  MTRXIN    CASECC,MATPOOL,EQDYN,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N,
               NOK2PP/V,N,NOM2PP/V,N,NOB2PP $
105  SAVE      NOK2PP,NOM2PP,NOB2PP $
106  EQUIV     M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA $
107  CHKPNT    K2PP,M2PP,B2PP,K2DD,M2DD,B2DD $
108  GKAD      USETD,GM,GO,,,,,K2PP,M2PP,B2PP/,,,GMD,GOD,K2DD,M2DD,B2DD/C,N,
               CMPLEV/C,N,DISP/C,N,MODAL/C,N,0.0/C,N,0.0/C,N,0.0/V,N,NOK2PP/V,
               N,NOM2PP/V,N,NOB2PP/ V,N,MPCF1/V,N,SINGLE/V,N,OMIT/V,N,NOUE/C,
               N,-1/C,N,-1/ C,N,-1/C,N,-1 $
109  CHKPNT    K2DD,M2DD,B2DD,GOD,GMD $
110  GKAM      USETD,PHIA,,LAMA,DIT,M2DD,B2DD,K2DD,CASECC/MHH,BHH,KHH,PHIDH/V,
               N,NOUE/C,Y,LMODES=0/C,Y,LFREQ=0./C,Y,HFREQ=0./V,N,  NOM2PP/V,N,
               NOB2PP/V,N,NOK2PP/V,N,NONCUP/V,N,FMODE/C,Y,KDAMP $
111  SAVE      NONCUP,FMODE $
112  CHKPNT    MHH,BHH,KHH,PHIDH $
113  APD       EDT,EQDYN,ECT,BGPDT,SILD,USETD,CSTM,GPLD/EQAERO,ECTA,BGPA,SILA,
               USETA,SPLINE,AERO,ACPT,FLIST,CSTMA,GPLA,SILGA/V,N,NK/V,N,NJ/V,
               N,LUSETA/V,N,BOV $
114  SAVE      NK,NJ,LUSETA,BOV $


115  PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,1 $
116  COND      SKPPLT,JUMPPLOT $
117  PARAM     //C,N,MPY/V,N,PLTFLG/C,N,0/C,N,1 $
118  PLTSET    PCDB,EQAERO,ECTA/PLTSETA,PLTPARA,GPSETSA,ELSETSA/V,N,NSIL1/V,N,
               JUMPPLOT $
119  SAVE      NSIL1,JUMPPLOT $
120  PRTMSG    PLTSETA // $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

AERO APPROACH, RIGID FORMAT 11

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


121  COND      SKPPLT,JUMPPLOT $
122  PLOT      PLTPARA,GPSETSA,ELSETSA,CASECC,BGPA,EQAERO, ,,,,/PLOTX2/V,N,
               NSIL1/V,N,LUSETA/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
123  SAVE      PFILE,JUMPPLOT,PLTFLG $
124  PRTMSG    PLOTX2 // $
125  LABEL     SKPPLT $
126  GI        SPLINE,USET ,CSTMA,BGPA,SIL , ,GM,GO/GTKA/V,N,NK/V,N,LUSET $
127  CHKPNT    GTKA $
128  PARAM     //C,N,ADD/V,N,DESTRY/C,N,0/C,N,1/ $
129  AMG       AERO,ACPT/AJJL,SKJ,D1JK,D2JK/V,N,NK/V,N,NJ/V,N,DESTRY/ $
130  SAVE      DESTRY $
131  CHKPNT    AJJL,SKJ,D1JK,D2JK $
132  COND      NODJE,NODJE $
133  INPUTT2   /D1JE,D2JE,,,/C,Y,P1=0/C,Y,P2=11/C,Y,P3=XXXXXXXX $
134  LABEL     NODJE $
135  PARAM     //C,N,ADD/V,N,XQHHL/C,N,1/C,N,0 $
136  AMP       AJJL,SKJ,D1JK,D2JK,GTKA,PHIDH,D1JE,D2JE,USETD,AERO/QHHL,QKHL,
               QHJL/V,N,NOUE/V,N,XQHHL/V,Y,GUSTAERO=-1 $
137  SAVE      XQHHL $
138  CHKPNT    QHHL,QHJL,QKHL $
139  FPLG      CASECC,USETD,DLT,FRL,GMD,GOD,DIT,PHIDH/PPF,PSF,PDF,FOL,PHF1/
               C,N,MODAL/V,N,FREQY/V,N,APP $


140  SAVE      FREQY,APP $
141  CHKPNT    PPF,PSF,PDF,FOL,PHF1 $
142  PARAM     //C,N,NOT/V,N,NOFRY/V,N,FREQY $
143  PURGE     PPF/NOFRY $
144  CHKPNT    PPF $
145  GUST      CASECC,DLT,FRL,DIT,QHJL,,,ACPT,CSTMA,PHF1/PHF/ V,N,NOGUST/V,N,
```

```
RIGID FORMAT DMAP LISTING
SERIES P

AERO APPROACH, RIGID FORMAT 11

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

                BOV/C,Y,MACH/C,Y,Q $
146  SAVE       NOGUST $
147  EQUIV      PHF1,PHF/NOGUST $
148  CHKPNT     PHF $
149  FRRD2      KHH,BHH,MHH,QHHL,PHF,FOL/UHVF/V,N,BOV/C,Y,Q/C,Y,MACH $
150  CHKPNT     UHVF $
151  EQUIV      UHVF,UHVT/FREQY/FOL,TOL/FREQY $
152  CHKPNT     UHVT,TOL $
153  COND       IFTSKP,FREQY $
154  IFT        UHVF,CASECC,TRL,FOL/UHVT,TOL/C,Y,IFTM=0 $
155  CHKPNT     UHVT,TOL $
156  LABEL      IFTSKP $
157  MODACC     CASECC,TOL,UHVT,,,/TOL1,UHVT1,,,/V,N,APP $
158  ADR        UHVT1,CASECC,QKHL,TOL1,SPLINE,SILA,USETA/PKF/V,N,BOV/   C,Y,
                MACH/V,N,APP $
159  VDR        CASECC,EQDYN,USETD,UHVT1,TOL1,XYCDB,/OUHV1,/V,N,APP/C,N,MODAL/
                C,N,0/V,N,NOH/V,N,NOP/V,N,FMODE $
160  SAVE       NOH,NOP $
161  COND       NOH,NOH $
162  SDR3       OUHV1,,,,,/OUHV2,,,,, $
163  OFP        OUHV2,,,,,//V,N,CARDNO $
164  SAVE       CARDNO $

165  COND       NOH,NOXYCDB $
166  XYTRAN     XYCDB,OUHV2,,,,/XYPTTA/V,N,APP/C,N,HSET/V,N,PFILE/V,N,CARDNO/V,
                N,NOXYPL $
167  SAVE       PFILE,CARDNO,NOXYPL $
168  COND       NOH,NOXYPL $
169  XYPLOT     XYPTTA $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

AERO APPROACH, RIGID FORMAT 11

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


170  LABEL    NOH $
171  PARAM    //C,N,AND/V,N,PJUMP/V,N,NOP/V,N,JUMPPLOT $
172  COND     FINIS,PJUMP $
173  SDR1     USETD,,PHIDH,,,GOD,GMD,,KFS,,/PHIP,,QP/C,N,1/C,N,DYNAMICS $
174  EQUIV    PHIDH,PHIAH/NOUE $
175  COND     NOUE1,NOUE $
176  VEC      USETD/EVEC/C,N,D/C,N,A/C,N,E $
177  PARTN    PHIDH,,EVEC/PHIAH,,,/C,N,1 $
178  LABEL    NOUE1 $
179  MPYAD    GTKA,PHIAH,/PHIK/C,N,1/C,N,1/C,N,0/V,N,PREC $
180  UMERGE   USETA,PHIP,/PHIPS/C,N,PS/C,N,P/C,N,SA $
181  UMERGE   USETA,PHIPS,PHIK/PHIPA/C,N,PA/C,N,PS/C,N,K $
182  CHKPNT   PHIPA $
183  UMERGE   USETA,QP,/QPA/C,N,PA/C,N,P/C,N,PS $
184  CHKPNT   QPA $
185  SDR2     CASECC,CSTMA,MPT,DIT,EQAERO,SILA,,,BGPA,LAMA,QPA,PHIPA,EST,
              XYCDB,/ ,MQP1,MPHIPA1,MES1,MEF1,/C,N,MMREIG $
186  COND     NOPF,NOFRY $
187  SDR2     CASECC,,,,EQDYN,,,,,PPF,,,,XYCDB,/QPP1,,,,,/C,N,FREQ $
188  SDR3     QPP1,,,,,/QPP2,,,,,/ $
189  LABEL    NOPF $


190  SDR3     MPHIPA1,MES1,MEF1,MQP1,,/MPHIPA2,MES2,MEF2,MQP2,, $
191  DDRMM    CASECC,UHVT1,TOL1,MPHIPA2,MQP2,MES2,MEF2,XYCDB,EST,MPT,DIT/
              OUPV2,OQP2,OES2,OEF2, $
192  OFP      OUPV2,,OES2,OEF2,OQP2,//V,N,CARDNO $
193  SAVE     CARDNO $
194  COND     P2,JUMPPLOT $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

AERO APPROACH, RIGID FORMAT 11

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

195  MPYAD    PHIPA,UHVT1,/UVT1/C,N,0 $
196  SDR2     CASECC,CSTMA,,,EQAERO,,,,BGPA,TOL,,UVT1,,,/,,,,,,PUVPAT/APP $
197  PLOT     PLTPARA,GPSETSA,ELSETSA,CASECC,BGPA,EQAERO,SILGA,,PUVPAT,,/
              PLOTX3/V,N,NSIL1/V,N,LUSETA/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
198  PRTMSG   PLOTX3// $
199  LABEL    P2 $
200  COND     FINIS,NOXYCDB $
201  XYTRAN   XYCDB,,OQP2,OUPV2,OES2,OEF2/XYPLTT/V,N,APP/C,N,PSET/ V,N,PFILE/
              V,N,CARDNO/V,N,NOXYPL $
202  SAVE     PFILE,CARDNO,NOXYPL $
203  COND     NOXYPLTT,NOXYPL $
204  XYPLOT   XYPLTT $
205  LABEL    NOXYPLTT $
206  COND     FINIS,NOFRY $
207  COND     FINIS,NOPSDL $
208  RANDOM   XYCDB,DIT,PSDL,OUPV2,,OQP2,OES2,OEF2,CASECC/PSDF,AUTO/   V,N,
              NORN $
209  SAVE     NORN $
210  COND     FINIS,NORN $
211  XYTRAN   XYCDB,PSDF,AUTO,,,/XYPLTR/C,N,RAND/C,N,PSET/V,N,PFILE/   V,N,
              CARDNO/V,N,NOXYPL $
212  SAVE     PFILE,CARDNO,NOXYPL $

213  COND     FINIS,NOXYPL $
214  XYPLOT   XYPLTR $
215  JUMP     FINIS $
216  LABEL    ERROR2 $
217  PRTPARM  //C,N,-2/C,N,AERORESP $
218  LABEL    ERROR1 $
```

```
RIGID FORMAT DMAP LISTING
SERIES P

AERO APPROACH, RIGID FORMAT 11

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


219   PRTPARM  //C,N,-1/C,N,AERORESP $
220   LABEL    ERROR4 $
221   PRTPARM  //C,N,-4/C,N,AERORESP $
222   LABEL    FINIS $
223   END      $
```

3.21.2 Description of DMAP Operations for Aeroelastic Response

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

5. Go to DMAP No. 218 and print error message if no grid points are present.

6. GP2 generates Element Connection Table with internal indices.

11. GP3 generates Grid Point Temperature Table (element temperature).

12. TA1 generates element tables for use in matrix assembly and stress recovery.

14. Go to DMAP No. 218 and print error message if no elements have been defined.

17. EMG generates structural element stiffness and mass matrix tables and dictionaries for later assembly.

19. Go to DMAP No. 22 if no stiffness matrix is to be assembled.

20. EMA assembles stiffness matrix $[K^{x}_{gg}]$ and Grid Point Singularity Table.

23. Go to DMAP No. 218 and print error message if no mass matrix exists.

24. EMA assembles mass matrix $[M_{gg}]$.

26. Go to DMAP No. 29 if no weight and balance request.

27. GPWG generates weight and balance information.

28. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

30. Equivalence $[K^{x}_{gg}]$ to $[K_{gg}]$ if no general elements.

32. Go to DMAP No. 37 if no general elements.

33. SMA3 forms the general element stiffness matrix $[K^{y}_{gg}]$.

35. ADD combines the structural stiffness matrix $[K^{x}_{gg}]$ with the general element stiffness matrix $[K^{y}_{gg}]$ to obtain the stiffness matrix $[K_{gg}]$.

38. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

41. GPSP determines if possible grid point singularities remain.

43. Go to DMAP No. 45 if no grid point singularities remain.

44. ØFP formats table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

46. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

47. Go to DMAP No. 51 if MCE1 and MCE2 have already been executed for the current set of multipoint constraints.

48. MCE1 partitions multipoint constraint equations $[R_g] = [R_m | R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

49. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \begin{bmatrix} \bar{K}_{nn} & K_{nm} \\ K_{mn} & K_{mm} \end{bmatrix} \quad \text{and} \quad [M_{gg}] = \begin{bmatrix} \bar{M}_{nn} & M_{nm} \\ M_{mn} & M_{mm} \end{bmatrix}$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m], \text{ and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m] .$$

53. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

54. Go to DMAP No. 56 if no single-point constraints.

55. SCE1 partitions out single-point constraints

$$[K_{nn}] = \begin{bmatrix} K_{ff} & K_{fs} \\ K_{sf} & K_{ss} \end{bmatrix} \quad \text{and} \quad [M_{nn}] = \begin{bmatrix} M_{ff} & M_{fs} \\ M_{sf} & M_{ss} \end{bmatrix}$$

58. Equivalence $[K_{ff}]$ to $[K_{aa}]$ and $[M_{ff}]$ to $[M_{aa}]$ if no omitted degrees of freedom.

62. Go to DMAP No. 81 if no omitted coordinates.

64. VEC generates an f-size partitioning vector (V) for the o- and a-sets

$$\{u_f\} \rightarrow \{u_o\} + \{u_a\}$$

65. PARTN partitions constrained stiffness matrix using V.

$$[K_{ff}] = \begin{bmatrix} \bar{K}_{aa} & K_{ao} \\ K_{oa} & K_{oo} \end{bmatrix}$$

67. DECØMP decomposes $[K_{oo}]$ into lower and upper triangular factors $[L_{oo}]$ and $[U_{oo}]$.

69. Go to DMAP No. 71 if $[K_{oo}]$ is singular.

70. Go to DMAP No. 73 if $[K_{oo}]$ is not singular.

72. PRTPARM prints all parameters when $[K_{oo}]$ is singular.

75. FBS solves for the transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$.

77. MPYAD performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

79. SMP2 partitions constrained stiffness matrix

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oo}][G_o] + [G_o^T][M_{oa}].$$

82. Go to DMAP No. 91 if no free-body supports.

83. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] \text{ and } [M_{aa}] = \left[\begin{array}{c|c} M_{\ell\ell} & M_{\ell r} \\ \hline M_{r\ell} & M_{rr} \end{array}\right]$$

85. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

87. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}]$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D] ,$$

and calculates and outputs rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||}$$

89. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

92. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal to external grid point numbers (GPLD), including extra points introduced for dynamic analysis (SILD), and prepares Transfer Function Pool (TFPØØL), and Eigenvalue Extraction Data (EED).

94. Go to DMAP No. 216 and print error message if no Eigenvalue Extraction Data.

95. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

96. READ extracts real eigenvalues and vectors from the equation

$$[K_{aa} - \lambda M_{aa}]\{\phi_a\} = 0 ,$$

calculates rigid body modes by finding a matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized and computes rigid body eigenvectors

$$[\phi_{ao}] = \begin{bmatrix} D\,\phi_{ro} \\ \hline \phi_{ro} \end{bmatrix} ,$$

and calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass

99. ØFP formats the summary of eigenvalue extraction information (ØEIGS) prepared by READ and places it on the system output file for printing.

101. Go to DMAP No. 220 and print error message if no eigenvalues found.

102. ØFP formats the eigenvalues (LAMA) prepared by READ and places them on the system output file for printing.

104. MTRXIN selects the direct input matrices $[K^2_{pp}]$, $[M^2_{pp}]$, and $[B^2_{pp}]$.

106. Equivalence $[M^2_{pp}]$ to $[M^2_{dd}]$, $[B^2_{pp}]$ to $[B^2_{dd}]$, and $[K^2_{pp}]$ to $[K^2_{dd}]$ if no constraints applied.

108. GKAD applies constraints to direct input matrices $[K^2_{pp}]$, $[M^2_{pp}]$, and $[B^2_{pp}]$, forming $[K^2_{dd}]$, $[M^2_{dd}]$, and $[B^2_{dd}]$ and forms $[G_{md}]$ and $[G_{od}]$.

110. GKAM selects eigenvectors to form $[\phi_{dh}]$ and assembles stiffness, mass, and damping matrices in modal coordinates.

$$[K_{hh}] = \begin{bmatrix} k_i & 0 \\ \hline 0 & 0 \end{bmatrix} + [\phi_{dh}^T][K^2_{dd}][\phi_{dh}] ,$$

$$[M_{hh}] = \begin{bmatrix} m_i & 0 \\ \hline 0 & 0 \end{bmatrix} + [\phi_{dh}^T][M^2_{dd}][\phi_{dh}] ,$$

$$[B_{hh}] = \begin{bmatrix} b_i & 0 \\ \hline 0 & 0 \end{bmatrix} + [\phi_{dh}^T][B^2_{dd}][\phi_{dh}] ,$$

where

KDAMP = 1 (default)	KDAMP = -1
m_i = modal masses	m_i = modal masses
$b_i = m_i\ 2\pi\ f_i\ g(f_i)$	$b_i = 0$
$k_i = m_i\ 4\pi^2\ f_i^2$	$k_i = (1+ig(f_i))\ 4\pi^2\ f_i^2\ m_i$

113. APD processes the aerodynamic data cards from EDT. It adds the k points and the SA points to USETD making USETA. EQAERØ, ECTA, BGPA, CSTMA, GPLA, and SILA are updated to reflect the new elements. AERØ and ACPT reflect the aerodynamic parameters. SILGA is a special SIL for plotting.

116. Go to DMAP No. 125 if no plot output is requested.

118. PLTSET transforms user input into a form used to drive structure plotter.

120. PRTMSG prints error messages associated with structure plotter.

121. Go to DMAP No. 125 if no undeformed aerodynamic or structural element plots are requested.

122. PLØT generates all requested undeformed aerodynamic and structural element plots.

124. PRTMSG prints plotter data and engineering data for each undeformed aerodynamic and structural element plot generated.

126. GI forms a transformation matrix $[G_{ka}^T]$ which interpolates between aerodynamic (k) and structural (a) degrees of freedom.

129. AMG forms the aerodynamic matrix list $[A_{jj}]$, the area matrix $[S_{kj}]$, and the downwash coefficients $[D_{jk}^1]$ and $[D_{jk}^2]$.

132. Go to DMAP No. 134 if no user-supplied downwash coefficients.

133. INPUTT2 provides the user-supplied downwash factors due to extra points ($[D_{je}^1]$, $[D_{je}^2]$). PARAM NØDJE must be set to enter these matrices. The downwash w_j on box j due to the motion of an extra point, u_e, is given by $\{w_j\} = [D_{je}^1 + ik\, D_{je}^2]\{u_e\}$.

136. AMP computes the aerodynamic matrix list related to the modal coordinates as follows:

$$[\phi_{dh}] = \left[\begin{array}{c|c} \phi_{ai} & \phi_{ae} \\ \hline \phi_{ei} & \phi_{ee} \end{array}\right]$$

$$[G_{ki}] = [G_{ka}^T]^T[\ _{ai}]$$

$$[D_{ji}^1] = [D_{jk}^1]^T[G_{ki}]$$

$$[D_{ji}^2] = [D_{jk}^2]^T[G_{ki}]$$

$$[D_{jh}^1] \Leftarrow [D_{ji}^1 \mid D_{je}^1]$$

$$[D_{jh}^2] \Leftarrow [D_{ji}^2 \mid D_{je}^2]$$

For each (m,k) pair:

$$[D_{jh}] = [D_{hg}^1] + ik[D_{jh}^2]$$

for each group:

$$[Q_{jh}] = [A_{jj}^T]_{group}^{-1}[D_{jh}]_{group}$$

$$[Q_{kh}] = [S_{kj}][Q_{jh}]$$

$$[Q_{ih}] = [G_{ki}]^T[Q_{kh}]$$

$$[Q_{hh}] \Leftarrow \left[\frac{Q_{ih}}{Q_{eh}=0}\right]$$

139. FRLG forms the dynamic load vector $\{P_h\}$ from the frequency response data or transient data using a Fourier Transform.

145. GUST forms the loading due to gusts and adds to the direct loads.

147. Equivalence {PHF1} to {PHF} if no gust loads.

149. FRRD2 solves for the modal displacements using

$$[-M_{hh}\omega^2 + iB_{hh}\omega + K + qQ_{hh}(k)]U_h = P_h(\omega) .$$

151. Equivalence {UHVF} to {UHVT} and FØL to TØL if frequency response formulation.

153. Go to DMAP No. 156 if frequency response formulation.

154. IFT does in Inverse Fourier Transform of the displacements for transient formulation.

157. MØDACC uses data from ØFREQ or ØTIME data cards to select solutions for data recovery.

158. ADR produces aerodynamic load output (PKF) for selected points in frequency response only.

159. VDR prepares solution set displacements (ØUHV1), sorted by frequency or time, for output. The solution set includes mode amplitudes and extra points.

161. Go to DMAP No. 170 if output sorted by frequency or time step.

162. SDR3 prepares requested output sorted by solution set points.

163. ØFP formats tables prepared by SDR3 for output sorted by solution set point.

165. Go to DMAP No. 170 if no X-Y plots requested.

166. XYTRAN prepares the input for X-Y plotting of solution set points versus time or frequency.

168. Go to DMAP No. 170 if no plots possible as requested.

172. Go to DMAP No. 222 if no output for physical points requested.

173. SDR1 recovers physical displacements (PHIP) and forces of constraint (QP) for the real eigenvectors associated with the modes.

174. Equivalence $\{\phi_{dh}\}$ to $\{\phi_{ah}\}$ if no extra points introduced for dynamic analysis.

175. Go to DMAP No. 178 if no extra points present.

176. VEC generates a d-size partitioning vector (EVEC) for the a- and e-sets

$$\{u_d\} \rightarrow \{u_a\} + \{u_e\}$$

177. PARTN performs partition of $\{\phi_{dh}\}$ using EVEC.

$$\{\phi_{dh}\} \Rightarrow \begin{Bmatrix} \phi_{ah} \\ \hline 0 \end{Bmatrix}$$

179. MPYAD recovers displacements at the aerodynamic points (k).

$$\{\phi_k\} = [G_{ka}^T]^T\{\phi_{ah}\}$$

180. UMERGE is used to expand $\{\phi_p\}$ to the ps-set.

181. UMERGE places $\{\phi_k\}$ in its proper place in the displacement vector

$$\{\phi_{pa}\} \Leftarrow \begin{Bmatrix} \phi_{ps} \\ \hline \phi_k \end{Bmatrix}$$

183. UMERGE is used to expand $\{Q_p\}$ to the pa-set.

185. SDR2 calculates element forces (MEF1) and stresses (MES1) and prepares eigenvectors (MPHIPA1) and single-point forces of constraint (MQP1) for output sorted by frequency or time.

186. Go to DMAP No. 189 if not frequency response.

187. SDR2 prepares load vectors for output (ØPP1) sorted by frequency.

188. SDR3 prepares requested load output sorted by point number.

190. SDR3 prepares requested modal quantities output sorted by point number.

191. DDRMM prepares a subset of the element forces (ØEF2) amd stresses (ØES2), displacement vectors (ØUPV2), and single-point forces of constraint (ØQP2) solutions for output sorted by point number or element number.

192. ØFP formats requested physical output prepared by DDRMM and places it on the system output file for printing.

194. Go to DMAP No. 199 if no deformed aerodynamic or structural element plots requested.

196. SDR2 prepares vectors for deformed plotting.

197. PLØT prepares all requested deformed aerodynamic and structural element plots.

198. PRTMSG prints plotter data and engineering data for each deformed plot generated.

200. Go to DMAP No. 222 if no X-Y plots requested and make normal exit.

201. XYTRAN prepares the input for physical point X-Y plots.

203. Go to DMAP No. 205 if no plots possible as requested.

204. XYPLØT prepares requested X-Y plots of displacements, forces, stresses, loads, or single-point forces of constraint versus frequency or time.

207. Go to DMAP No. 222 if transient response and make normal exit.

207. Go to DMAP No. 222 if no power spectral density functions or autocorrelation functions requested and make normal exit.

208. RANDØM calculates power spectral density functions (PSDF) and autocorrelation functions (AUTØ) using the previously calculated frequency response.

210. Go to DMAP No. 222 if no X-Y plots of RANDØM Calculations requested and make normal exit.

211. XYTRAN prepares the input for requested X-Y plots of the RANDØM output.

213. Go to DMAP No. 222 if no plots possible as requested and make normal exit.

214. XYPLØT prepares requested X-Y plots of autocorrelation functions and power spectral density functions.

215. Go to DMAP No. 222 and make normal exit.

217. MØDAL AERØELASTIC RESPØNSE ERRØR NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

219. MØDAL AERØELASTIC RESPØNSE ERRØR NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

221. MØDAL AERØELASTIC RESPØNSE ERRØR NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

3.21.3 Case Control Deck and Parameters for Aeroelastic Response Analysis

The following items relate to subcase definition and data selection for Modal Aeroelastic Response:

1. METHØD must appear above the subcase level to select eigenvalue extraction method.
2. At least one subcase must be defined for each unique set of direct input matrices (K2PP, M2PP, B2PP) or frequencies.
3. Consecutive subcases for each set of direct input matrices or frequencies are used to define the loading condition - one subcase for each dynamic loading condition.
4. Constraints must be defined above the subcase level.
5. DLØAD must be used to define a frequency-dependent loading condition for each subcase. If transient loads are selected, a Fourier Transform is used to compute frequency-dependent loads. All loads in one run must be of the same type.
6. FREQUENCY must be used to select one, and only one, FREQ, FREQ1, or FREQ2 card from the Bulk Data Deck. If TLØADs are selected, a TSTEP must be selected.
7. ØFREQUENCY (ØTIME) may be used above the subcase level or within each subcase to select a subset of the solution frequencies (times) for output requests. The default is to use all solution frequencies (times).
8. If Random Response calculations are desired, RANDØM must be used to select RANDPS and RANDTi cards from the Bulk Data Deck. Only one ØFREQUENCY and FREQUENCY card can be used for each set of direct input matrices.

The Real Eigenvalue Summary Table and Real Eigenvalue Analysis Summary, as described under Normal Mode Analysis, are automatically printed.

The following printed output, sorted by point number or element number (SØRT2), is available, either as real and imaginary parts or magnitude and phase angle (0° - 360° lead), for the list of frequencies specified by ØFREQUENCY (in transient formulations, these are real):

1. Displacements, velocities, and accelerations for a list of PHYSICAL points (grid points and extra scalar points introduced for dynamic analysis) or SØLUTIØN points (points used in formulation of the general K system). Velocities and accelerations are not available for transient analysis.

2. Nonzero components of the applied load vector and single-point forces of constraint for a list of PHYSICAL points. Aerodynamic forces on selected aerodynamic elements.

3. Stress and forces in selected elements (ALL available only for SØRT1).

The following printed output is available for Random Response calculations:

1. Power spectral density function and mean deviation for the response of selected components for points or elements. The expected frequency of zero crossings.

2. Autocorrelation function for the response of selected components for points or elements.

The following plotter output is available:

1. Undeformed plot of the structural model.

2. Deformed shapes of the aerodynamic and structural model for selected intervals.

3. X-Y plot of any component of displacement, velocity, or acceleration of a PHYSICAL point or SØLUTIØN point.

4. X-Y plot of any component of the applied load vector or single-point force of constraint.

5. X-Y plot of any stress or force component for an element.

The following plotter output is available for Random Response calculations:

1. X-Y plot of the power spectral density versus frequency for the response of selected components for points or elements.

2. X-Y plot of the autocorrelation versus time lag for the response of selected components for points or elements.

The data used for preparing the X-Y plots may be punched or printed in tabular form (see Section 4.2). Also, a printed summary is prepared for each X-Y plot which includes the maximum and minimum values of the plotted function.

The following parameters are used in Aeroelastic Response calculations:

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - These parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

4. LFREQ and HFREQ - Required unless LMØDES is used. The real values of these parameters give the frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation. The default value for each parameter is 0.0.

5. LMØDES - Required unless LFREQ and HFREQ are used. The integer value of this parameter is the number of lowest modes to be used in the modal formulation. The default value is 0.

6. KDAMP - optional in aeroelastic response. If set to +1, modal damping is put into a complex stiffness matrix as structural damping. The default value is 1.

7. GUSTAERØ - optional in aeroelastic response. An integer value of +1 causes gust loads to be computed. The default value is 1.

8. IFTM - optional in aeroelastic response. The value of this parameter selects the method for the integration of the Inverse Fourier Transform. The integer 0 specifies a rectangular fit; 1 specifies a trapezoidal fit; and 2 specifies a cubic spline fit. The default value is 0.

9. MACH - optional in aeroelastic response. The real value of this parameter selects the closest Mach numbers to be used to compute aerodynamic matrices. The default value is 0.0.

10. Q - Real, required in aeroelastic response. The real value of this parameter defines the dynamic pressure.

11. NØDJE - optional in aeroelastic response. A positive integer for this parameter indicates user supplied downwash matrices due to extra points are to be read from tape via the INPUTT2 module in the rigid format. The default value is -1 when not needed.

12. P1, P2, and P3 - required in aeroelastic response when using NØDJE parameter. See Section 5.3.2 for tape operation parameters required by INPUTT2 module. The defaults for P1, P2, and P3, as defined in the rigid format, are 0,11, and XXXXXXXX, respectively.

3.21.4 The APPEND Feature

The APPEND feature can be used for real eigenvalue extraction in Modal Aeroelastic Response. See Section 3.4.7 for details.

4. PLOTTING

4.1 PLOTTING

NASTRAN provides the capability for generating on any of several different plotters the following kinds of plots:

1. Undeformed geometric projections of the structural model.
2. Static deformations of the structural model by either displaying the deformed shape (alone or superimposed on the undeformed shape), or displaying the displacement vectors at the grid points (superimposed on either the deformed or undeformed shape).
3. Modal deformations (sometimes called mode shapes or eigenvectors) resulting from real eigenvalue analysis by the same options stated in 2 above. Complex modes of flutter analysis may be plotted for any user chosen phase lag.
4. Deformations of the structural model for transient response or frequency response by displaying either vectors or the deformed shape for specified times or frequencies.
5. X-Y graphs of transient response (time), frequency response (frequency), or static response (subcase).
6. V-f and V-g graphs of flutter analysis.
7. Topological displays of matrices.
8. Contour plots of stress and displacement. To avoid crowded output an outline of the model may be optionally requested.

Structure plots (items 1-4) are discussed in Section 4.2 while X-Y plots (item 5) are discussed in Section 4.3. Matrix plots are generated by Utility Module SEEMAT described in Section 5 and must be accomplished by altering a Rigid Format or using a DMAP sequence. Requests for structure plots or X-Y plots are accomplished in the Case Control Deck by sumbitting a structure plot request packet or an X-Y output request packet. The discussion of these packets constitutes most of the remainder of this chapter. The optional PLØTID card is considered to be part of the plot packets, although it must precede any ØUTPUT(PLØT), ØUTPUT(XYØUT), or ØUTPUT(XYPLØT) cards (See the PLØTID card in Section 2.3).

In order to actually create plots, a plotter and model name must be specified by the user. The method used to specify this information may vary according to the plot request made, but the actual names used do not vary. In addition, a physical plot tape or mass storage area must be set up by the user. The system control cards needed to generate plots are generally installation dependent and are described in Section 5 of the Programmer's Manual. There are two plot files (PLT1 and PLT2). It is only necessary to specify file PLT2. File PLT1 is reserved for future use.

The following table shows the permissible plotters and model names. The underlined items are the default models for each plotter. A model name is generally specified as two items, each having a default value. The default value of the second item is in some cases dependent upon the value specified for the first item. If no plotter is specified by the user, the requested plots will be created for the Stromberg Carlson (SC) model 4020 microfilm plotter.

Plotter Names and Models	
Name	Model
SC	4020
CALCØMP	{7651, 7631, 7655, 7635}, {781, 780, 773, 772, 771, 770} {5651, 5631, 5655, 5635}, {763, 762, 761, 760, 751, 750}
NASTPLT	{M, T, D}, {0, 1}

The plotter name, SC, is used for Stromberg Carlson plotters. The only permissible model is the 4020 microfilm plotter. If the only available plotter model is a 4060, the user should determine if it has a 4020 compatibility package.

The plotter name, CALCØMP, is used for California Computer plotters. The default model is a 7651,770. The first model item contains the three digits which refer to the plotter model number as used in California Computer hardware descriptions plus an additional digit referring to the increment size. The 700 series plotters are those having 16 incremental directions. The 500 series plotters are those having only 8 incremental directions. The 600 series may have either 16 or 8 incremental directions. If the user has access to only a 663 or 665 plotter, it should be specified as a 563 or 565 if it has only 8 incremental directions, and as a 763 or 765 if it has 16 incremental directions. The 563 and 763 are both 30-inch drum plotters, while the 565 and 765 are both 12-inch drum plotters.

There are two possible increment sizes, .010 and .005 inch. The last digit of the first model item represents these two possible increment sizes, i.e., 1 = .010 and 5 = .005.

The second model item indicates the type of tape transport used with the CALCØMP plotter and the number of spacers for tape densities. The first two digits of the second model item represent the type of tape transport attached to the plotter. There are numerous types of tape transports available. The primary differences among these transports are the number of characters per plot command. The 750 transport requires three characters per plot command and can only be attached to the 500 series plotters. All other transports require one character. The 760 transport is used with either the 500 or 600 series plotters. The 770 and 780 transports are used with the 600 or 700 series plotters.

The complete CALCØMP plotter card encompasses two model item codes which represent a combination of plotter model number, increment size, tape transport model number, and spacer numbers for tape densities. The following table illustrates the item codes required for the hardware available.

Calcomp Plotter Parameters								
External Model Name	Plotter Model	Increment Size (in.)	Paper Size X by Y (in. x in.)	Transport	Number of Spacers (ns)			
					A	B	C	D
7651,78{ns}	765	.01	12 X 11	780	-	0	-	1
7651,77{ns}	765	.01	12 X 11	770	0	1	2	3
7655,78{ns}	765	.005	12 X 11	780	-	0	-	1
7655,77{ns}	765	.005	12 X 11	770	0	1	2	3
7631,78{ns}	763	.01	30 X 29	780	-	0	-	1
7631,77{ns}	763	.01	30 X 29	770	0	1	2	3
7635,78{ns}	763	.005	30 X 29	780	-	0	-	1
7635,77{ns}	763	.005	30 X 29	770	0	1	2	3
5651,76{ns}	565	.01	12 X 11	760	0	1	2	3
5651,75{ns}	565	.01	12 X 11	750	0	1	2	3
5655,76{ns}	565	.005	12 X 11	760	0	1	2	3
5655,75{ns}	565	.005	12 X 11	750	0	1	2	3
5631,76{ns}	563	.01	30 X 29	760	0	1	2	3
5631,75{ns}	563	.01	30 X 29	750	0	1	2	3
5635,76{ns}	563	.005	30 X 29	760	0	1	2	3
5635,75{ns}	563	.005	30 X 29	750	0	1	2	3

A = 200 bpi tape on fast tape transport
B = 556 bpi tape on slow tape transport
C = 800 bpi tape on slow tape transport
D = 800 bpi tape on fast tape transport
Plot tapes may be seven or nine tracks (See Section 2.1).

The plotter name, NASTPLT, is used for the NASTRAN General Purpose plotter package. This plotter package is used if the user's plotter is not supported by the NASTRAN plotting software. However, if this package is specified, a separate program must be written to interpret the resulting plot tape and create the corresponding plots on the actual plotter desired. The default model is M, 1. The first model item may either be M, T, or D to indicate the actual plotter is a microfilm, table or drum plotter, respectively. The second model item indicates whether or not the actual plotter has any typing capability: 0 means typing possible, 1 means no typing possible. If no typing capability exists, all printed characters will be drawn. The default plotter type is a microfilm plotter with no typing capability. An example of an acceptable model is (T,1). This represents a table plotter having no typing capability. A more detailed description of the implications of the NASTRAN General Purpose plotter package is given in Section 6 of the Programmer's Manual.

The operation of the Structure Plotter is of sufficient theoretical content to warrant inclusion in the Theoretical Manual. Section 13 of the Theoretical Manual provides a discussion of the basic theory and gives some examples of plotter output.

The availability of NASTRAN plotting capability is a function of the particular rigid format as shown in Table 1.

NASTRAN PEN Designation	PLØTTER Pen Number
1	1
2	2
3	3
4	4
5	1
6	2
7	3
8	4

PTITLE	[blanks / BCD string]

The title may be up to 64 characters. This card defines the plot title for a series of plots. A plot title card remains in effect until a new plot title is defined. To eliminate a title, a new plot title card which contains only blanks must be defined.

The title card must preceed the PLØT card to which it pertains. If a PLØT card generates several plot frames, the preceeding title card will apply to all the frames.

CSCALE	[1.0 / cs]

This card is used to scale down the size of alphanumeric characters when using the general purpose plotter. The default value, 1.0, designates full size characters for TITLE, SUBTITLE, LABEL, PTITLE, grid point ID, and element ID. A character scale of .5 designates half size.

FIND [SCALE f],[ØRIGIN i],[VANTAGE PØINT],[SET j],[REGIØN le,be,re,te]

f = ratio by which the scale is multiplied after it is calculated.

i = origin identification number (any positive integer).

j = set identification number (any positive integer).

le = fractional distance of left edge of plot region from the lower left corner of the image area (default value = 0.0).

be = fractional distance of bottom edge of plot region from the lower left corner of the image area (default = 0.0).

re = fractional distance of right edge of plot region from the lower left corner of the image area (default value = 1.0).

te = fractional distance of top edge of plot region from the lower left corner of the image area (default value = 1.0).

The FIND card requests the structure plotter to compute any of the parameters SCALE, ØRIGIN i and/or VANTAGE PØINT indicated by the user based on (a) the plotter requested on the PLØTTER card, (b) the projection requested on the PRØJECTION card, (c) SET j and REGIØN le, be, re, te requested on the FIND card, (d) the orientation requested on the VIEW and/or AXES card(s), (e) the deformation scaling requested on the MAXIMUM DEFØRMATION card, and (f) the paper size for table plotters as requested on the PAPER SIZE card. All dependencies on which a FIND card is based must precede the FIND card.

Any one, two, or all three parameters may be computed by the program by using the card, provided that the parameters not requested have already been defined. If no set is specified on this card, the first set defined is used by default. If no options are specified on the FIND card, a SCALE and VANTAGE PØINT are selected and ØRIGIN 1 is located, using the first defined SET, so that the plotted object is located within the image area. The plot region is defined as some fraction of the image area (image area = 0., 0., 1., 1. and first quadrant = .5, .5, 1., 1.). The image area is located inside the margins on the paper. Each FIND card must be one (1) logical card. The FIND card is recommended for general use.

The contour plot definition card is used to specify the type of contour plot and the contour values to be plotted. The card is optional since all parameters may be defaulted.

CØNTØUR [stress / displacement] , [EVEN 10 / LIST c1,c2,...,cn / EVEN n] , [Z1 / Z2 / MAX / MID] , [CØMMØN / LØCAL] direction

Nine types of stress coutour plots are available:

stress = { MAJPRIN / MINPRIN } - Major and Minor Principal Stress
stress = MAXSHEAR - Maximum Shear Stress
stress = { XNØRMAL / YNØRMAL / ZNØRMAL } - X, Y, and Z Components of the Normal Stress
stress = { XYSHEAR / XZSHEAR / YZSHEAR } - XY, XZ, and YZ Components of the Shear Stress

Four types of displacement contour plots are available:

displacement = { XDISPLAC / YDISPLAC / ZDISPLAC } - the X, Y, and Z components of the displacement vector
displacement = MAGNITUD - the magnitude of the displacement vector

Default for this parameter is MAJPRIN, Major Principal Stress.

If stress contour is requested, contour lines will be plotted on the following elements appropriate to the type of stress contour plot requested: SHEAR, TRIA1, TRIA2, QUAD1, QUAD2, TRMEM, and QDMEM.

If displacement contour is requested, contour lines will be plotted on all two-dimensional elements plotted by the structure plotter. The type of deformation must be specified for displacement contours since there is no default.

The contour lines are labeled with integers indicating the contour value. The integers are listed with their associated contour values under MESSAGES FRØM THE PLØT MØDULE in the printed output.

The contour values to be plotted may be specified by supplying the parameter EVEN and the number, n, of contour values, or by supplying LIST with a list of real number contour values. If EVEN is specified, the contour plotter will calculate n contour values at (n-1) equal intervals over the range of values specified by the user. The first contour value will be the minimum and the n-th contour value the maximum of the values for the current set of elements. The maximum number of contour values, n, is 50. Default for this parameter is "EVEN 10", i.e., contour values at 10 equal intervals.

Since stress may be calculated at two fibre distances, the fibre distance may be specified by designating Z1 (Fibre Distance 1) or Z2 (Fibre Distance 2). In addition, MAX, the maximum of Z1 and Z2, or MID, the average of Z1 and Z2, may be selected. The average of Z1 and Z2 (MID) is applicable only to the TRIA2 and QUAD2 elements. The Fibre Distance Z1 must be used for TRMEM, QDMEM, and SHEAR elements. The default is Z1.

The Normal Stresses are directional and are calculated in the elements' local coordinate system. If CØMMØN direction is specified, the contour plotter will transform the Normal Stresses and the Shear Stresses to a common (the basic) coordinate system. If LØCAL direction is specified, the contour plotter will leave these stresses in the global coordinate system. Note that the Normal Z Stress, and the Shear-XZ and Shear-YZ are assumed to be zero in the element's local coordinate system. Default for this parameter is the CØMMØN direction.

The following table summarizes the recognizable options associated with stress contour requests.

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY.

```
CAMERA {FILE}      [BLANK FRAMES {n}]
       {PAPER}                {1}
       {BØTH }

PAPER SIZE {a   } {x } {b    }     ,[TYPE {BCD value}]
           {8.5} {BY} {11.0}           { VELLUM    }

PTITLE [blanks    ]
       [BCD string]

CSCALE [1.0]
       [cs ]
```

FIND Card - Optional

```
FIND [SCALE f],[ØRIGIN]i,[VANTAGE PØINT],[SET j], [REGIØN le, be, re, te]
```

CØNTØUR Card - Optional

```
CØNTØUR [stress      ] , [EVEN 10          ] , [Z1 ] , [{CØMMØN} direction]
        [displacement]   [LIST c1,c2,....,cn]   [Z2 ]  {LØCAL }
                         [EVEN n             ]  [MAX]
                                                [MID]
```

PLØT Execution Card - Required

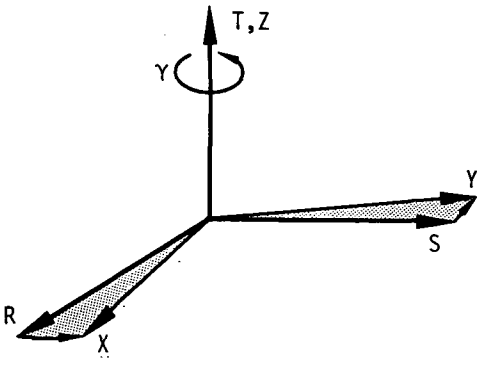
```
PLØT [{STATIC      }]  [{DEFØRMATIØN}][CØNTØUR] [i1, i2 THRU i3, etc.] [{RANGE f1, f2}][{PHASE LAG  φ}],
     [{MØDAL       }]  {VELØCITY    }          {RANGE λ1, λ2}{MAGNITUDE }
     [{CMØDAL      }]  {ACCELERATIØN}          {TIME  t1, t2}
     [{FREQUENCY   }]
     [{TRANSIENT   }]

[MAXIMUM DEFØRMATIØN d],

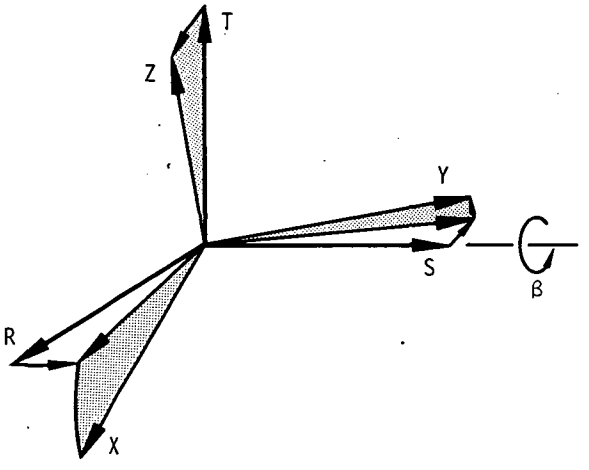
[SET j1][ØRIGIN k1] [{SYMMETRY    } w][{PEN    } p] [SYMBØLS m[, n]] [LABEL [GRID PØINTS]],
                    {ANTISYMMETRY}   {DENSITY}                          [ELEMENTS  ]
                                                                        [BØTH      ]
                                                                        [EPID      ]

[SHAPE          ]
[VECTØR v       ]
[SHAPE, VECTØR v] ,
[ØUTLINE        ]

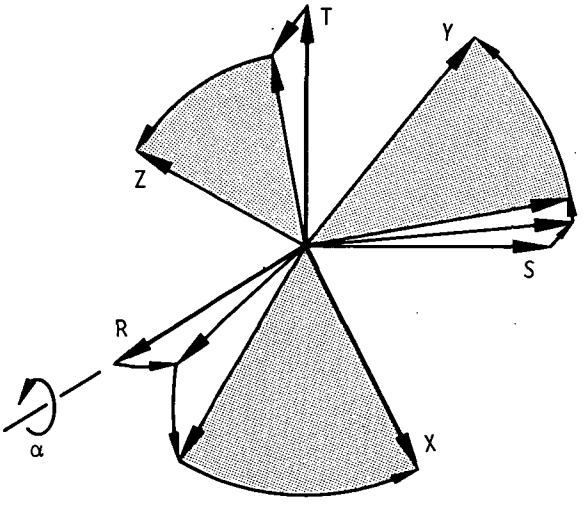
[SET j2][ØRIGIN k2] .... etc.
```



(a) γ - rotation about T-axis.



(b) β — rotation about S-axis



(c) α - rotation about R-axis

Figure 1. Plotter coordinate system-model orientation.

4.3.2 Parameter Definition Cards

4.3.2.1 Cards Pertaining to All Curves

1. PLØTTER = plotter name, model name

 Selects plotter; required if plots are requested. Plotter choices are listed in Section 4.1, but there is no default. (Note: one or both of the plot tapes must be set up. See Section 5 of the Programmer's Manual for instructions.)

2. CAMERA = c (Integer)

 Used for microfilm plotters only to select camera as follows: $c \leq 1$ for film, $c = 2$ for paper, $c \geq 3$ for both; default value is 3.

3. PENSIZE = ps (Integer ≥ 0)

 Used to select pen for table plotter; default value is 1. (See Section 4.2.2.2)

4. DENSITY = d (Integer ≥ 0)

 Used to select line density for microfilm plotters only; default value is 1. A line density of d is d times heavier than a line density of 1.

5. SKIP = s (Integer ≥ 0)

 Used to insert s blank frames between requested frames for microfilm plotters; default value is 1.

6. XPAPER = x (Real)
 YPAPER = y (Real)

 Defines paper size (x by y) for table plotters; default value is x = 8.5 inches and y = 11.0 inches.

7. CSCALE = cs (Real)

 Used to scale down the size of alphanumeric characters from full size when using the general purpose plotter. Default is 1.0. A character scale of .5 is half size.

8. XMIN = x1 (Real)
 XMAX = x2 (Real)

 Specifies limits of x1 and x2 as abscissa of curve; default values are chosen so as to accommodate all points.

9. XLØG = {YES / NØ}

 Request for logarithmic x-coordinate, default value is NØ. Default value for tic division interval depends on number of log cycles (see table at end of this section).

10. YAXIS = {YES / NØ}

 Request for plotting y-axis; default value is NØ.

11. XINTERCEPT = xi (Real)

 Location on the x-axis (xi) where the y-axis will be drawn; default value is 0.0.

12. UPPER TICS = ut (Integer*)

 Any integer value (ut) causes tic marks to be drawn on the upper edge of the frame; default value is integer one.

13. LØWER TICS = lt (Integer*)

 Any integer value (lt) causes tic marks to be drawn on the lower edge of the frame; default value is integer one.

14. CURVELINESYMBØL = cls (Integer)

 Request for points to be connected by lines (cls = 0), identified by symbol |cls| (cls < 0), or both (cls > 0); default value is 0; see Section 4.2.2.3 for the list of symbols. If cls ≠ 0, subsequent curves on the same frame will cause cls to be incremented by one (decrement by one if cls < 0) for each curve and thus cycle through the available symbols.

15. XDIVISIØNS = xd (Integer > 0)

 Applies xd uniform spaces along the x-direction for whichever of the following are called for: UPPER TICS, LØWER TICS, XAXIS; default value is 5 spaces; not applicable to log scales.

16. XVALUE PRINT SKIP = xps (Integer ≥ 0)

 Request for values to be placed on x-tic marks. The number of tic marks to be skipped between labeled tic marks is xps; default value is integer zero.

17. CLEAR

 Causes all parameter values except PLØTTER and titles (XTITLE, YTITLE, YTTITLE, YBTITLE, TCURVE) to revert to their default values.

18. XTITLE = {any legitimate character string}

 Title to be used with x-axis.

19. TCURVE = {any legitimate character string}

 Curve title.

The default values for tic divisions on log plots are given in the following table, but will range over whole cycles:

Number of Cycles	Intermediate Values
1, 2	2., 3., 4., 5., 6., 7., 8., 9.
3	2., 3., 5., 7., 9.
4	2., 4., 6., 8.
5	2., 5., 8.
6, 7	3., 6.
8, 9, 10	3.

4.3.2.2 Cards Pertaining Only to Whole Frame Curves

1. YMIN = y1 (Real)
 YMAX = y2 (Real)

 Specifies y1 and y2 as limits of ordinate of curve; default values are chosen so as to accommodate all points.

*See note on page 4.3-8.

4.3.5 Summary of X-Y Output Request Packet Cards

Type of value: I = Integer, R = Real, B = BCD, yesno = YES or NØ. See Sections 4.3.2 and 4.3.3 for details of these cards.

Items pertaining to all plots

1.	PLØTTER	= p	(B)
2.	CAMERA	= c	(I)
3.	PENSIZE	= ps	(I)
4.	DENSITY	= d	(I)
5.	SKIP	= s	(I)
6.	XPAPER	= x	(R)
	YPAPER	= y	(R)
7.	CSCALE	= cs	(R)
8.	XMIN	= x1	(R)
	XMAX	= x2	(R)
9.	XLØG	= yesno	(B)
10.	XAXIS	= yesno	(B)
11.	XINTERCEPT	= xi	(R)
12.	UPPER TICS	= ut	(I)
13.	LØWER TICS	= lt	(I)
14.	CURVLINESYMBØL	= cls	(I)
15.	XDIVISIØNS	= xd	(I)
16.	XVALUE PRINT SKIP	= xps	(I)
17.	CLEAR		-
18.	XTITLE	= {anything}	(B)
19.	TCURVE	= {anything}	(B)

	Whole frames only		Upper half frames only		Lower half frames only		
1	YMIN	= y1	YTMIN	= yt1	YBMIN	= yb1	(R)
	YMAX	= y2	YTMAX	= yt2	YBMAX	= yb2	(R)
2	XAXIS	= yesno	XTAXIS	= yesno	XBAXIS	= yesno	(B)
3	YINTERCEPT	= yi	YTINTERCEPT	= yti	YBINTERCEPT	= ybi	(I)
4	YLØG	= yesno	YTLØG	= yesno	YBLØG	= yesno	(B)
5	LEFT TICS	= lt	TLEFT TICS	= tlt	BLEFT TICS	= blt	(I)
6	RIGHT TICS	= rt	TRIGHT TICS	= trt	BRIGHT TICS	= brt	(I)
7	ALLEDGE TICS	= aet	TALL EDGE TICS	= taet	BALL EDGE TICS	= baet	(I)
8	YDIVISIØNS	= yd	YTDIVISIØNS	= ytd	YBDIVISIØNS	= ybd	(I)
9	YVALUE PRINT SKIP	= yps	YTVALUE PRINT SKIP	= ytps	YBVALUE PRINT SKIP	= ybps	(I)
10	XGRID LINES	= yesno	XTGRID LINES	= yesno	XBGRID LINES	= yesno	(B)
11	YGRID LINES	= yesno	YTGRID LINES	= yesno	YBGRID LINES	= yesno	(B)
12	YTITLE	= {anything}	YTTITLE	= {anything}	YBTITLE	= {anything}	

Command operation cards

{XYPLØT, XYPRINT, XYPUNCH, XYPEAK, XYPAPLØT}

{ACCE, DISP, ELFØRCE, NØNLINEAR, ØLØAD, SACCE, SDISP, SPCF, STRESS, SVELØ, VECTØR, VELØ, VG}

{RESPØNSE, AUTØ, PSDF}

subcases /curves

5. DIRECT MATRIX ABSTRACTION

5.1 GENERAL

In addition to using the rigid formats provided automatically by NASTRAN, the user may wish to execute a series of modules in a different manner than provided by the rigid format. Or, he may wish to perform a series of matrix operations which are not contained in any existing rigid format. If the modifications to an existing rigid format are minor, the ALTER feature described in Section 2 may be employed. Otherwise, a user-written Direct Matrix Abstraction Program (DMAP) should be used.

DMAP is the user-oriented language used by NASTRAN to solve problems. A rigid format is basically a collection of statements in this language. DMAP, like English or FØRTRAN, has many grammatical rules which must be followed to be interpretable by the NASTRAN DMAP compiler. Section 5.2 provides the user with the rules of DMAP which will allow him to understand the rigid format DMAP sequences, write ALTER packages, and construct his own DMAP sequences using the many modules contained in the NASTRAN DMAP repertoire.

Section 5.3 is an index of matrix, utility, user and executive DMAP modules which are contained in Sections 5.4 thru 5.7 respectively.

Sections 5.4 thru 5.7 describe individually the many nonstructurally oriented modules contained in the NASTRAN library. Section 5.8 provides several examples of DMAP usage.

User-written modules must conform to the rules and usage conventions described herein.

Section 5.8 illustrates the use of DMAP operations in both the standard method (as rigid formats are written) and in the improved method.

Section 5.9 describes the automatic alters to a rigid format which result from each of the Automated Multi-stage Substructuring commands invoked by the user.

Section 5.10 contains descriptions and uses of functional modules which are of general utility to the user but have not been permanently incorporated into the rigid formats.

5.2 DMAP RULES

Grammatically, DMAP instructions consist of two types: Executive Operation Instructions and Functional Module Instructions. Grammatical rules for these two types of instructions will be discussed separately in subsequent sections.

Functional modules are arbitrarily classified as structural modules, matrix operation modules, utility modules, or user-generated modules.

The DMAP sequence itself consists of a series of DMAP instructions or statements, the first of which is BEGIN or XDMAP and the last of which is END. The remaining statements consist of Executive Operation instructions and Functional Module calls.

5.2.1 DMAP Rules for Functional Module Instructions

The primary characteristic of the Functional Module DMAP instruction is its prescribed format. The general form of the Functional Module DMAP statement is:

```
MØD   I1,I2,---,Im/Ø1,Ø2,---,Øn/a1,b1,p1/a2,b2,p2----/az,bz,pz  $
```

```
   where   MØD is the DMAP Functional Module name,
           Ii; i = 1,m are the Input Data Block names,
           Øi; i = 1,n are the Øutput Data Block names,
   and     ai,bi,pi; i = 1,z are the Parameter Sections.
```

In the general form shown above, commas (,) are used to separate several like items while slashes (/) are used to separate sections from one another. The module name is separated from the rest of the instruction by a blank or a comma (,). The dollar sign ($) is used to end the instruction and is not required unless the instruction ends in the delimiter /. A DMAP statement is restricted to columns 1 through 72. Information beyond column 72 is ignored. If the entire DMAP instruction does not fit on one card, the last delimiter (not followed by a $ sign) causes the next card to be read as a continuation. Thus, one DMAP instruction may require several cards. Blanks may be used in conjunction with any of the above delimiters for ease of reading. If it is desired to preserve the output alignment of the printed instructions, the module name is begun in column 1 and the rest of the instruction is begun in column 10 when supplying alters to a Rigid Format.

A functional module communicates with other modules and the executive system entriely through its inputs, outputs and parameters. The characteristics or attributes of each functional module are contained in the Module Properties List (MPL) described in Section 2.4 of the Programmer's

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY.

Manual and are reflected in the DMAP Module Descriptions that follow in Section 5.3 and in the Module Functional Descriptions contained in Chapter 4 of the Programmer's Manual. The module name is a BCD value (which consists of an alphabetic character followed by up to seven additional alphanumeric characters) and must correspond to an entry in the MPL. A Data Block name may be either a BCD value or null. The absence of a BCD value indicates that the Data Block is not needed for a particular application.

5.2.1.1 Functional Module DMAP Statements

Each Functional Module DMAP statement must conform to the MPL regarding:

1. Name spelling
2. Number of input data blocks
3. Number of output data blocks
4. Number of parameters
5. Type of each parameter

Note: See Sections 5.2.1.3 and 5.2.1.4 for allowable exceptions to these rules.

5.2.1.2 Functional Module Names

The only Functional Module DMAP names allowed are those contained in the MPL. Therefore, if a user wishes to add a module, he must either use one of the User Module names provided (see Section 5.6) or add a name to the MPL. The Programmer's Manual should be consulted when adding a new module to NASTRAN.

5.2.1.3 Functional Module Input Data Blocks

In most cases an input data block should have been previously defined in a DMAP program before it is used. However, there may be instances in which a module can handle, or may even expect, a data block to be undefined at the time the module is initially called. An input data block is previously defined if it appears as an output data block in a previous DMAP instruction, as output from the Input File Processor, any user-input (via Bulk Data Cards) DMI or DTI data block name, or exists on the Old Problem Tape in a restart problem. Although the number of data blocks is prescribed, if any number of final data blocks are null, they may be omitted from the section. For example, the module TABPT, which uses five input data blocks, may be defined by:

```
TABPT   GEØM1,,,, //  $
```

or

```
TABPT   GEØM1 //  $
```

A potentially fatal error message (See Section 5.2.1.7) will be issued at compilation time to warn the user that a discrepancy in the data block name list has been detected. This is also true in the event that a previously undefined data block is used as input. Also, see the "error-level" option on the XDMAP compiler option card which may be invoked by the user to terminate execution in the event of such errors.

5.3 INDEX OF DMAP MODULE DESCRIPTIONS

Descriptions of all nonstructurally oriented Modules are contained herein, arranged alphabetically by category as indicated by the lists below. Descriptions for the structurally oriented modules are contained in Section 4 of the Programmer's Manual. They are listed here in order to provide a complete list of all NASTRAN Modules. Additional information regarding nonstructurally oriented modules is also given in Section 4 of the Programmer's Manual.

Matrix Operation Modules (13)
(See Section 5.4)

ADD
ADD5
DECØMP
FBS
MERGE
MPYAD
PARTN
SDCMPS
SMPYAD
SØLVE
TRNSP
UMERGE
UPARTN

Utility Modules (26)
(See Section 5.5)

CØPY
DIAGØNAL
INPUT
INPUTT1
INPUTT2
LAMX
MATGPR
MATPRN
MATPRT
ØUTPUT1
ØUTPUT2
ØUTPUT3
PARAM
PARAML
PARAMR
PRTPARM
SCALAR
SEEMAT
SETVAL
SWITCH
TABPCH
TABPRT
TABPT
TIMETEST
VEC

User Modules (14)
(See Section 5.6)

DDR
DUMMØD1
DUMMØD2
DUMMØD3
DUMMØD4
INPUTT3
INPUTT4
MØDA
MØDB
MØDC
ØUTPUT
ØUTPUT4
PARTVEC
XYPRNPLT

Executive Operation Modules (14)
(See Section 5.7)

BEGIN
CHKPNT
CØND
END
EQUIV
EXIT
FILE
JUMP
LABEL
PRECHK
PURGE
REPT
SAVE
XDMAP

Substructure DMAP ALTERs (19)
(See Section 5.9)

BRECØVER
CHECK
CØMBINE
DELETE
DESTRØY
DUMP
EDIT
EQUIV
PLØT
RECØVER
REDUCE
RENAME
RESTØRE
RUN
SØFIN
SØFØUT
SØFPRINT
SØLV
SUBSTRUCTURE

Supplementary Functional Modules (2)
(See Section 5.10)

EMA1
GPSPC

In the examples that accompany each description, the following notation is used:

1. Upper case letters and special symbols in the DMAP calling sequence must be punched as shown except for data block names, parameter names, and label names which are symbolic.
2. Lower case letters represent constants whose permissible values are indicated in the descriptive text.

Due to the many possible forms which may be used when writing parameters, a variety of arbitrarily selected forms will be used in the examples. This does not imply that the form used in any example is required or that it is the only acceptable form allowed.

The terms form, type, and precision are used in many functional module descriptions. By form is meant one of the following:

Form	Meaning
1	Square
2	Rectangular
6	Symmetric

By type is meant one of the following:

Type	Meaning
1	Real, single precision
2	Real, double precision
3	Complex, single precision
4	Complex, double precision

By precision is meant one of the following:

Precision Indicator	Meaning
1	Single precision numbers
2	Double precision numbers

I. NAME: UMERGE (Merges two matrices based on USET)

II. PURPOSE: To merge two column matrices (such as load vectors or displacement vectors) into a single matrix.

III. DMAP CALLING SEQUENCE:

UMERGE USET,PHIA,PHIØ / PHIF / V,N,MAJØR=F / V,N,SUBO=A / V,N,SUB1=L $

IV. INPUT DATA BLOCKS:

USET - displacement set definitions

PHIA, PHIØ } any matrices

Note: 1. The set definitions may be USET (statics), USETD (dynamics), HUSET (heat transfer), or USETA (aeroelastic).

2. USET, USETD, HUSET, or USETA may not be purged.

3. PHIA or PHIØ may be purged in which case their respective elements will be zero.

4. PHIA, PHIØ and PHIF must be related by the following matrix equation

$$\left\{\frac{\text{PHIA}}{\text{PHIØ}}\right\} \Longrightarrow \{\text{PHIF}\}$$

V. OUTPUT DATA BLOCKS:

PHIF - matrix

Note: PHIF must not be purged.

VI. PARAMETERS:

MAJØR - BCD value from table below (Input, no default)

SUBO - BCD value from table below (Input, no default)

SUB1 - BCD value from table below (Input, no default)

Note: The set equation MAJØR = SUBO + SUB1 should hold.

parameter value	USET matrix
M	U_m
S	U_s (union of SG and SB)
Ø	U_o
R	U_r
G	U_g
N	U_n
F	U_f
A	U_a
L	U_ℓ
SG	U_s (specified on Grid card)
SB	U_s (specified on SPC card)
E	U_e
P	U_p

DIRECT MATRIX ABSTRACTION

NE	U_{ne} (union of N and E)
FE	U_{fe} (union of F and E)
D	U_{d}
PS	U_{ps}
SA	U_{sA}
K	U_{k}
PA	U_{pA}

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY.

I. NAME: UPARTN (Partitions a matrix based on USET)

II. PURPOSE: To perform symmetric partitioning of matrices (particularly to allow user splitting of long running modules such as SMP1).

III. DMAP CALLING SEQUENCE:

UPARTN USET,KII / KJJ,KLJ,KJL,KLL / V,N,MAJØR=I / V,N,SUBO=J / V,N,SUB1=L $

IV. INPUT DATA BLOCKS:

USET - displacement set definitions

KII - Any displacement matrix

Note: 1. The set definitions may be USET (statics), USETD (dynamics), HUSET (heat transfer), or USETA (aeroelastic).

2. USET may not be purged.

3. KII may be purged in which case UPARTN will simply return, causing the output matrices to be purged.

V. OUTPUT DATA BLOCKS:

KJJ, KLJ, KJL, KLL } matrix partitions

Note: 1. Any or all output data block(s) may be purged.

2. UPARTN forms:

$$[K_{ii}] \Longrightarrow \left[\begin{array}{c|c} K_{jj} & K_{j\ell} \\ \hline K_{\ell j} & K_{\ell\ell} \end{array}\right]$$

VI. PARAMETERS:

MAJØR - BCD value from table below (Input, no default)

SUBO - BCD value from table below (Input, no default)

SUB1 - BCD value from table below (Input, no default)

Note: The set equation MAJØR = SUBO + SUB1 should hold.

parameter value	USET matrix
M	U_m
S	U_s (union of SG and SB)
Ø	U_o
R	U_r
G	U_g
N	U_n
F	U_f

MATRIX OPERATIONS MODULES

A	U_a
L	U_ℓ
SG	U_s (specified on Grid card)
SB	U_s (specified on SPC card)
E	U_e
P	U_p
NE	U_{ne} (union of N and E)
FE	U_{fe} (union of F and E)
D	U_d
PS	U_{ps}
SA	U_{sA}
K	U_k
PA	U_{pA}

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY.

5.5 UTILITY MODULES

Module	Basic Function	Page
CØPY	Generate a physical copy of a data block	5.5-2
DIAGØNAL	Strip diagonal from matrix	5.5-2a
INPUT	Generate most of bulk data for selected academic problems	5.5-3
INPUTT1	Read data blocks from GINØ-written user tapes	5.5-4
INPUTT2	Read data blocks from FØRTRAN-written tapes	5.5-10
LAMX	Edit or generate data block, LAMA	5.5-12a
MATGPR	Displacement set matrix printer	5.5-13
MATPRN	Print Matrices	5.5-15
MATPRT	Print Matrices associated only with geometric grid points	5.5-16
ØUTPUT1	Write data blocks via GINØ onto user tapes	5.5-17
ØUTPUT2	Write data blocks via FØRTRAN onto user tapes	5.5-24
ØUTPUT3	Punch matrices onto DMI cards	5.5-28
PARAM	Manipulate Parameter values	5.5-30
PARAML	Selects parameters from a user input matrix or table	5.5-32
PARAMR	Performs specified arithmetic, logical and conversion operations on real or complex parameters	5.5-33
PRTPARM	Print parameter values and DMAP error	5.5-35
SCALAR	Convert Matrix element to parameter	5.5-39
SEEMAT	Generate Matrix Topology Displays	5.5-40
SETVAL	Set parameter values	5.5-43
SWITCH	Interchange two data block names	5.5-43a
TABPCH	Punch NASTRAN tables on DTI cards	5.5-44
TABPRT	Print selected table data blocks using readable format	5.5-45
TABPT	Print table data blocks	5.5-47
TIMETEST	Provides NASTRAN system timing data	5.5-48
VEC	Generate partitioning vector	5.5-49

Utility modules are an arbitrary sub-division of the Functional Modules and are used to output matrix and table data blocks and to manipulate parameters.

The data block names correpsonding to the various matrix and table data blocks used in the Rigid Format DMAP sequences may be found in Section 3 or in the NASTRAN mnemonic dictionary, Section 7.

I. NAME: CØPY

II. PURPOSE: To generate a physical copy of a data block.

III. DMAP CALLING SEQUENCE:

CØPY DB1 / DB2 / PARAM $

IV. INPUT DATA BLOCKS:

DB1 - Any NASTRAN data block

V. OUTPUT DATA BLOCKS:

DB2 - Any valid NASTRAN data block name

VI. PARAMETERS:

PARAM - If PARAM < 0 the copy will be performed - integer, input, default = -1.

VII. METHOD: If PARAM $\geq$ 0 a return is made, otherwise a physical copy of the input data block is generated.

VIII. REMARKS:

1. The input data block may not be purged.

I. NAME: MATGPR (Displacement Set Matrix Printer)

II. PURPØSE: Prints matrices associated with set definitions. External grid point identification of each nonzero element is also printed.

III. DMAP CALLING SEQUENCE:

A. For matrices generated in Rigid Formats 1-6 or matrices generated in Rigid Formats 7-12 prior to module GKAD (or GKAM):

```
MATGPR  GPL,USET,SIL,M // C,N,c / C,N,r $
```

B. For matrices generated in Rigid Formats 7-12 after module GKAD (or GKAM);

```
MATGPR  GPLD,USETD,SILD,M // C,N,c / C,N,r $
```

IV. INPUT DATA BLØCKS:

GPL - Grid Point List
GPLD - Grid Point List (Dynamics)
USET - Displacement Set Definition (Statics)
USETD - Displacement Set Definition (Dynamics)
HUSET - Displacement Set Definition (Heat Transfer)
USETA - Displacement Set Definition (Aeroelastic)
SIL - Scalar Index List
SILD - Scalar Index List (Dynamics)
M - Any displacement set matrix

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS:

1. c-row size (number of columns) - must be the appropriate BCD value from the table below. (Input, no default)

2. r-column size (number of rows) - must be the appropriate BCD value from the table below. If not specified, it will be assumed that r=c. (Input, default = X which implies r=c)

MATGPR parameter value	Means matrix is same size as
M	U_m
S	U_s (union of SG and SB)
Ø	U_o
R	U_r
G	U_g
N	U_n
F	U_f
A	U_a
L	U_ℓ
SG	U_s (specified on GRID card)

SB	U_s (specified on SPC card)
E	U_e
P	U_p
NE	U_{ne} (union of N and E)
FE	U_{fe} (union of F and E)
D	U_d
PS	U_{ps}
SA	U_{sA}
K	U_k
PA	U_{pA}

Notes:

1. See Section 1.4 for a discussion of set notation.
2. If the value specified for c is not in the above table, the matrix will not be printed.
3. The user must know which sets correspond to the rows and columns of the matrix he wishes to print. This is usually apparent from the DMAP name of the matrix data block.

VII. REMARKS:

1. When using the form specified in IIIA, this module may not be scheduled until after GP4 since data blocks generated by GP4 are required inputs. When using the form specified in IIIB, this module may not be scheduled until after DPD since data blocks generated by DPD are required inputs.
2. If [M] is purged, no printing will be done.
3. The non-zero terms of the matrix will be printed along with the external grid point and component identification numbers corresponding to the row and column position of each term.

Param	Special Operations
op	ØUT
NØP	ØUT (unchanged)
KLØCK	Current CPU time in integer seconds from the start of the job.
TMTØGØ	Remaining CPU time in integer seconds based on the TIME card.
PREC	Returns the currently requested precision; single precision (1) or double precision (2).
DIAG	Turn on DIAGs IN1 through IN2. IN1 $\geq$ IN2 will turn on DIAG IN1 IN1 < IN2 will turn on DIAG IN1 through DIAG IN2
DIAGØFF	Turn off DIAGs IN1 through IN2 as used for DIAG.
SSST	Turns DIAG \|ØUT\| on if ØUT > 0. Turns DIAG ØUT off if ØUT $\leq$ 0.
SSSR	Saves DIAG IN1 in ØUT if IN1 $\geq$ 0. Restores DIAG \|IN1\| to ØUT if IN1 < 0.
STSR	Saves SYSTEM(IN1) in ØUT if IN1 $\geq$ 0. Restores SYSTEM(IN1) to ØUT if IN1 < 0. (SYSTEM(IN1) is the IN1-th word in /SYSTEM/ common block.)
SYSR	Stores the value of IN1 from /SYSTEM/ into ØUT.
SYST	Sets the value from /SYSTEM/ where IN1 is the word and IN2 is the value of the parameter.

2. PARAM does its own SAVE; therefore a SAVE is not needed following the module.

VIII. EXAMPLES:

1. To change the sense of parameter NØXYZ (which may be useful for the CØND or EQUIV instructions):

```
PARAM // C,N,NØT / V,N,XYZ / V,N,NØXYZ $ or
PARAM // *NØT* / XYZ / NØXYZ $
```

Alternatively, XYZ could have been set in the following way:

```
PARAM // C,N,MPY / V,N,XYZ / V,N,NØXYZ / C,N,-1 $ or
PARAM // *MPY* / XYZ / NØXYZ / -1 $
```

2. `PARAM // C,N,IMPL / V,N,ABC / V,N,DEF / V,N,GHI $`

3. To set the value of parameter P1 to 5 and save it for subsequent use:

```
PARAM // C,N,NØP / V,N,P1=5 $ or
PARAM // *NØP* / P1=5 $
```

4. To set parameter ABC to +1:

```
PARAM // C,N,EQ / V,N,ABC / C,N,2 / C,N,-3 $ or
PARAM // *EQ* / ABC / 2 / -3 $
```

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY

MATERIAL PREVIOUSLY ON PAGES 5.5-37 AND 5.5-38 HAS BEEN DELETED

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY.

Plotter Name	Model Identifiers
SC	4020,0
CALCØMP	{7651, 7631, 7655, 7635}, {781, 780, 773, 772, 771, 770} {5651, 5631, 5655, 5635}, {763, 762, 761, 760, 751, 750}
NASTPLT	{M,0, T,0, D,0, M,1, T,1, D,1}

5. The parameter modelnl is used to specify the first of the two model identifiers when it is an integer value. The default value for the fifth parameter is 0.

6. The parameter modelbl is used to specify the first of the two model identifiers when it is a BCD value. The default value for the sixth parameter is blank.

7. The parameter modeln2 is used to specify the second of the two model identifiers when it is an integer value. The default value for the seventh parameter is 0.

8. The parameter modelb2 is used to specify the second of the two model identifiers when it is a BCD value. The default value for the eighth parameter is blank.

9. The parameter sizex specifies the size of the plotter surface x-dimension on those plotters for which it is appropriate (e.g., the CALCØMP plotter). The default value for sizex is 30.0.

10. The parameter sizey specifies the size of the plotter surface y-dimension on those plotters for which it is appropriate (e.g., the CALCØMP plotter). The default value for sizey is 30.0.

VII. METHØD: The matrix is partitioned into blocks which can be printed on a single sheet of output paper or frame on the plotter selected. Only blocks containing nonzero elements will be output. Row and column indices are indicated. The user of this module is cautioned to make sure his line count limit is large enough. A default of 20,000 lines is provided by NASTRAN. This may be changed via the statement MAXLINES= value in the NASTRAN Case Control Deck. The transpose of the matrix is output.

VIII. REMARKS:

1. If a plotter is used, the file PLT2 (either tape or mass storage area) must be made available to NASTRAN.
2. If a plotter is used, a SAVE instruction should be executed to update PFILE.
3. The nonzero elements are indicated by asterisks (*), except for diagonal elements of square matrices which are indicated by the letter D, and elements in the last row or column which are indicated by dollar signs ($).
4. The default model for any plotter is specified by omitting the last four parameters.
5. When two of the last four parameters are used to specify model identifiers, the remaining two parameters should be specified as C,N only.

IX. EXAMPLES:

1. Specify CALCØMP 7651,770 as follows:

```
SEEMAT  M1,M2,M3,M4,M5 // C,N,PLØT / V,N,PFILE / C,N / C,N,CALCØMP $
```

2. Specify SC 4020 as follows:

```
SEEMAT  M1,M2,M3,M4,M5 // C,N,PLØT / V,N,PFILE $
```

3. Specify the general purpose plotter as follows:

```
SEEMAT  M1,M2,M3,M4,M5 // C,N,PLØT / V,N,PFILE / C,N / C,N,NASTPLT / C,N /
                          C,N,D / C,N,1 / C,N $
```

4. Specify the printer rather than a plotter as follows:

```
SEEMAT  M1,M2,M3,M4,M5 // $
```

5. For additional examples see Section 5.8.8.

I. NAME: VEC (Creates partitioning vector based on USET).

II. PURPOSE: To create a partitioning vector for matrices using USET that may be used by Matrix Operation Modules MERGE and PARTN. This allows the user to split up long running modules such as SMP1.

III. DMAP CALLING SEQUENCE:

A. For matrices generated in Rigid Formats 1-6 or prior to module GKAD (or GKAM) in Rigid Formats 7-12:

```
VEC  USET / V / C,N,SET / C,N,SET0 / C,N,SET1 / V,N,ID $
```

B. For matrices generated in Rigid Formats 7-12 after module GKAD (or GKAM):

```
VEC  USETD / V / C,N,SET / C,N,SET0 / C,N,SET1 / V,N,ID $
```

IV. INPUT DATA BLOCKS:

USET - displacement set definition (statics)
or
USETD - displacement set definition (dynamics)
or
HUSET - displacement set definition (heat transfer)
or
USETA - displacement set definition (aeroelastic)

Note: The set definition input data block may not be missing and must fit into open core.

V. OUTPUT DATA BLOCKS:

V - Partitioning vector.

Note: 1. If all elements are in SET0 or SET1 then V will be purged.
2. V may not be purged prior to execution.

VI. PARAMETERS:

SET - Matrix set to be partitioned (Input, BCD, no default).
SET0 - Upper partition of SET (Input, BCD, no default).
SET1 - Lower partition of SET (Input, BCD, no default).
ID - Identification of bit position (see table below) (Input, integer, default = 0).

Note: 1. Legal parameter values are given in the table below.
2. See Section 1.4 for a description of set notation.

parameter value	USET matrix	bit position
M	U_m	32
S	U_s (union of SG and SB)	31
Ø	U_o	30

R	U_o	29
G	U_r	28
N	U_n	27
F	U_f	26
A	U_a	25
L	U_ℓ	24
SG	U_s (specified on Grid card)	23
SB	U_s (specified on SPC card)	22
E	U_e	21
P	U_p	20
NE	U_{ne} (union of N and E)	19
FE	U_{fe} (union of F and E)	18
D	U_d	17
PS	U_{ps}	16
SA	U_{sA}	15
K	U_k	14
PA	U_{pA}	13

VII. REMARKS:

1. Parameters SET0 and SET1 must be a subset of the SET matrix parameter. A degree of freedom may not be in both subsets.
2. If desired, one of SET0 or SET1 but not both may be requested to be the complement of the other one by giving it a value of CØMP.
3. If SET = BITID, the second and third parameters are ignored and the IDth bit position in USET (or USETD) is used. In this case, SET is assumed equal to G (or P) and SET0 will correspond to the zero's in the IDth position and SET1 will correspond to the non-zer's in the IDth position.

VIII. EXAMPLES:

1. To partition $[K_{ff}]$ into a- and o- set based matrices, use

```
VEC   USET / V / C,N,F / C,N,Ø / C,N,A $
PARTN KFF,V, / KØØ,KAØ,KØA,KAA $
```

Note that the same thing can be done in one step by

```
UPARTN USET,KFF / KØØ,KAØ,KØA,KAA / C,N,F / C,N,P / C,N,A $
```

2. Example 1 could be accomplished by

```
VEC  USET / V / C,N,F / C,N,Ø / C,N,CØMP $
```

or

```
VEC  USET / V / C,N,F / C,N,CØMP / C,N,A $
```

3. Example 1 could be accomplished by

```
VEC  USET / V / C,N,BITID / C,N,X / C,N,X / C,N,25 $
```

5.9 AUTOMATIC SUBSTRUCTURE DMAP ALTERS

In the automated substructure process, the user commands (described in Section 2.7) are converted to the form of DMAP instructions via ALTER card equivalents. This section describes the resulting DMAP data for each command.

The "raw DMAP" data, stored in the program and modified according to the user input data, is listed by command type. The fields in the raw DMAP to be modified, or "variables", are underlined (i.e., XXX). The subcommand control cards are identified by parentheses on the right side. For example, the (P only) for the SUBSTRUCTURE command item 12, implies that this DMAP instruction is included only if the ØPTIØN request includes P (loads).

The ALTER card images are not true DMAP instructions but are used to locate positions in the existing DMAP Rigid Format for replacement by or insertion of the new DMAP instructions. The locations to be specified depend on the Rigid Format selected by the SØL Executive Control Card and are listed in Section 3 for each Rigid Format. The relevant section of the Rigid Format for each ALTER is indicated by the note in parentheses. For instance "After GP4" in Rigid Format 1 (statics) implies "ALTER 69" for insertion of the corresponding DMAP instructions following Rigid Format Series Ø instruction number 69. If an existing set of DMAP instructions is to be removed, the parenthetical note may indicate "Remove DECØMP", where DECØMP may be a set of NASTRAN modules related to the entire decomposition process.

The descriptions given below are highly dependent on the user input commands and the Rigid Format selected. For an exact listing of all DMAP data generated for the current set of substructure commands, the DIAG 23 Executive Control Card may be input. Adding DIAG 24 will produce a punched deck of the actual ALTER cards generated. This feature allows the user to modify these alters and execute under APP DMAP,SUBS.

5.9.1 Index of Substructure DMAP ALTERs

ALTER	Basic Function	Page
BRECØVER	Convert Phase 2 results to solution vectors	5.9-3
CØMBINE	Combine several substructures	5.9-4
CREDUCE	Complex modal reduction of a substructure	5.9-4a
DELETE, DESTRØY, EDIT, EQUIV, RENAME, SØFPRINT	Internal utility commands	5.9-5
MREDUCE	Real modal reduction of a substructure	5.9-5a
PLØT	Plot substructures	5.9-6
RECØVER, MRECØVER	Recover and output Phase 2 solution data or Phase 1,2 modal reduction data	5.9-7
REDUCE	Initiate matrix partitioning operations	5.9-8
RUN	Define the DRY parameter	5.9-9
SØFIN, SØFØUT, RESTØRE, DUMP, CHECK	File operators	5.9-10
SØLVE	Provide data for execution of the solution phase	5.9-11
SUBSTRUCTURE	Initiate the automatic DMAP process	5.9-12

DMAP for Command: BRECØVER (Phase 3)

The BRECØVER command converts the results of a Phase 2 substructure analysis to NASTRAN solution vectors for the detailed calculation of basic structure (or an equivalent basic substructure) displacements, forces, loads, and stresses. The same structure model of the primary substructure defined in Phase 1 must be used in Phase 3. It is possible to perform the Phase 3 execution either as a restart of the Phase 1 run or as an independent run, which recalculates the necessary data blocks.

Raw DMAP:

```
1   ALTER     (Remove solution)
2   PARAM     //*NØP*/ALWAYS=-1 $
3   SSG1      SLT,BGPDT,CSTM,SIL,EST,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/LUSET/
4             NSKIP $   (R.F. 9 only)                                        } (P or PA only)
5   SSG2      USET,GM,YS,KFS,GØ,,PG/QR,PØ,PS,PL $   (R.F. 1,2,3 or 9 only)
6   RCØVR3    ,PG,PS,PØ,YS/UAS ,QAS,PGS,PSS,PØS,YSS,LAMA/SØLN/*NAME    */
7             NDUE $
8   EQUIV     PGS,PG/ALWAYS $
9   EQUIV     PSS,PS/ALWAYS $
10  EQUIV     PØS,PØ/ALWAYS $
11  EQUIV     YSS,YS/ALWAYS $              (R.F. 1 or 2 only)                } (P or PA only)
12  CØND      LBSSTP,ØMIT $
13  FBS       LØØ,,PØS/UØØV/1/1/PREC/0 $
14  LABEL     LBSSTP $
15  ØFP       LAMA,,,,,//CARDNØ $   (R.F. 3 only)
16  ALTER     (After SDR1)
17  UMERGE    USET,QAS,/QGS/*G*/*A*/*Ø* $
18  ADD       QG ,QGS/QGT $
19  EQUIV     QGT,QG /ALWAYS $
20  EQUIV     CASECC,CASEXX/ALWAYS $   }
21  ALTER     (Remove repeat logic)    }  (R.F. 8 or 9 only)
```

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY.

Variables:

YS,PØ = Remove if not P or PA, or if not R.F. 1 or 2

PG,PS = Remove if not P or PA, or if not R.F. 1, 2, or 9

R.F.	1	2	3	8	9
UAS =	ULV	ULV	PHIA	UDVF	UDVT
PGS =	PGS	PGS			PPT
PSS =	PSS	PSS			PST
LAMA =			LAMA	PPF	TØL
QG =	QG	QG	QG	QPC	QP

PØS = Remove if not P or PA, or if not R.F. 1, 2, or 3

SØLN = Rigid Format solution number

NAME = Name of basic Phase 1 substructure, corresponding to input data

NØUE = Remove if not R.F. 8 or 9

STP = Step number

PREC = Precision

DMAP for Command: CØMBINE

The CØMBINE command initiates the process for combining several substructures defined on the SØF files. The CØMB1 module reads the control deck and the bulk data cards and builds the tables and transformation matrices for the combination structure. The CØMB2 module performs the matrix transformations using the matrices stored onthe SØF file or currently defined as NASTRAN data blocks. The resultant matrices are stored on the SØF file and retained as NASTRAN data blocks.

Raw DMAP:

```
1   CØMB1    CASECC,GEØM4//STP/S,N,DRY/*PVEC* $
2   CØND     LBSTP,DRY $
3   CØMB2    ,KN01,KN02,KN03,KN04,KN05,KN06,KN07/KNSC/S,N,DRY/*K*/*    */
4            *NAME0001*/*NAME0002*/*NAME0003*/*NAME0004*/*NAME0005*/
5            *NAME0006*/*NAME0007* $                                    } (K only)
6   SØFØ     ,KNSC,...,//S,N,DRY/*NAMEC   */*KMTX* $
7   CØMB2    ,MN01,MN02,MN03,MN04,MN05,MN06,MN07/MNSC/S,N,DRY/*M*/*    */
8            *NAME0001*/*NAME0002*/*NAME0003*/*NAME0004*/*NAME0005*/
9            *NAME0006*/*NAME0007* $                                    } (M only)
10  SØFØ     ,MNSC,...,//S,N,DRY/*NAMEC   */*MMTX* $
11  CØMB2    ,PN01,PN02,PN03,PN04,PN05,PN06,PN07/PNSC/S,N,DRY/*P*/*PVEC*/
12           *NAME0001*/*NAME0002*/*NAME0003*/*NAME0004*/*NAME0005*/
13           *NAME0006*/*NAME0007* $                                    } (P or PA only)
14  SØFØ     ,PNSC,,,,//S,N,DRY/*NAMEC   */*PVEC $
15  CØMB2    ,BN01,BN02,BN03,BN04,BN05,BN06,BN07/BNSC/S,N,DRY/*B*/*    */
16           *NAME0001*/*NAME0002*/*NAME0003*/*NAME0004*/*NAME0005*/
17           *NAME0006*/*NAME0007* $                                    } (B only)
18  SØFØ     ,BNSC,,,,//S,N,DRY/*NAMEC   */*BMTX* $
19  CØMB2    ,K4N01,K4N02,K4N03,K4N04,K4N05,K4N06,K4N07/K4NSC/S,N,DRY/*K4*/
20           *    */*NAME0001*/*NAME0002*/*NAME0003*/*NAME0004*/*NAME0005*/
21           *NAME0006*/*NAME0007* $                                    } (K4 only)
22  SØFØ     ,K4NSC,,,,//S,N,DRY/*NAMEC   */*K4MX* $
23  LABEL    LBSTP $
24  LØDAPP   PNSC,//*NAMEC   */S,N,DRY $   (PA only)
```

Variables:

STP	= Step number
PVEC	= PVEC for P option, PAPP for PA option
N01,N02,...etc.	= Internal numbers for structures to be combined
NSC	= Internal number of combined structure
NAME0001,NAME0002,...,etc.	= Names of pseudostructures to be combined
NAMEC	= Name of combined structure

DMAP for Command: CREDUCE

The CREDUCE command performs a complex modal synthesis reduction for a component substructure. The resulting generalized coordinates for the reduced substructure will consist of selected boundary point displacements and generalized displacements of the eigenvectors. The MRED1 module produces dummy USET and EED data blocks for the execution of the eigenvector extraction procedure. The EQST data block is created for use by the CMRED2 module. The CMRED2 module performs the actual matrix reduction. Note that, because the number of modal degrees of freedom is a calculated value, the RUN=DRY option is not allowed for complex modal reduction.

Raw DMAP:

```
 1  PARAM     //*NØP*/ALWAYS=-1 $
 2  MRED1     CASECC,GEØM4,DYNAMICS,CSTM/USETR,EEDR,EQST,DMR/*NAMEA    */
 3            S,N,DRY/STP/S,N,NØFIX/S,N,SKIPM/*COMPLEX* $
 4  CØND      LBM3STP,DRY $
 5  SØFI      /KNØA,MNØA,PNØA,BNØA,K4NØA/S,N,DRY/*NAMEA    */*KMTX*/*MMTX*/
 6            *PVEC*/*BMTX*/*K4MX* $
 7  CØND      LBM2STP,SKIPM $
 8  EQUIV     KNØA,KFFX/NØFIX $   (K only)
 9  EQUIV     MNØA,MFFX/NØFIX $   (M only)
10  EQUIV     BNØA,BFFX/NØFIX $   (B only)
11  EQUIV     K4NØA,K4FFX/NØFIX $   (K4 only)
12  CØND      LBM1STP,NØFIX $
13  SCE1      USETR,KNØA,MNØA,BNØA,K4NØA/KFFX,KFSX,KSSX,MFFX,BFFX,K4FFX $
14  LABEL     LBM1STP $
15  PARAMR    //*CØMPLEX*//1,0/GPARAM    /G $
16  ADD       KFFX,K4FFX/KDD/G/(0,0,1,0) $
17  EQUIV     KDD,KFFX/ALWAYS $
18  CEAD      KFFX,BFFX,MFFX,EEDR,/PHIDR,CLAMA,ØCEIGS,PHIDL/NEIGVS $
19  ØFP       CLAMA,ØCEIGS,,,,// $
20  EQUIV     PHIDR,PHIFR/NØFIX $
21  EQUIV     PHIDL,PHIFL/NØFIX $
22  CØND      LBM2STP,NØFIX $
23  UMERGE    USETR,PHIDR,/PHIFR/*N*/*F*/*S* $
24  UMERGE    USETR,PHIDL,/PHIFL/*N*/*F*/*S* $
25  LABEL     LBM2STP $
26  CMRED2    CASECC,CLAMA,PHIFR,PHIFL,EQST,USETR,KNØA,MNØA,BNØA,K4NØA,PNØA/
27            KNØB,MNØB,BNØB,K4NØB,PNØB,PØNØB/STP/S,N,DRY/*PVEC* $
28  LABEL     LBM3STP $
29  LØDAPP    PNØB,PØNØB//*NAMEB    */S,N,DRY $   (PA only)
30  CØND      FINIS,DRY $
```

(Remove for option PA)

Variables:

STP	= Step Number
PVEC	= PVEC for option P, PAPP for option PA
NAMEA	= Name of input substructure, A
NAMEB	= Name of output substructure, B
NØA	= Internal number of substructure A
NØB	= Internal number of substructure B
KFFX,KFSX,KSSX	= K only
MFFX	= M only
BFFX	= B only
K4FFX	= K4 only
CLAMA,PHIFR,PHIFL	= Remove for option PA

DMAP for Utility Commands: DELETE, DESTRØY, EDIT, EQUIV, RENAME, SØFPRINT

Several internal operations of the SØF may be performed with the utility commands which create various calls to the SØFUT module. Each of the commands and associated data are inserted as parameters.

Raw DMAP:

```
1   SØFUT       //DRY/*NAME    */*ØPER*/ØPT/*NAMEØØØ2*/*PREF*/*ITM1*/*ITM2*/
2               *ITM3*/*ITM4*/*ITM5* $
```

Variables:

NAME = Name of substructure
ØPER = Operation to be performed (first four characters of command, i.e., EDIT)
ØPT = Integer option code
NAMEØØØ2 = Second substructure name for EQUIV and RENAME
PREF = Prefix for EQUIV operation
ITM1,ITM2, etc. = SØF data item names

The following chart describes the variables used for each command.

Command	NAME	ØPER	ØPT	NAMEØØØ2	PREF	ITM1, etc.
DELETE	X	X				X
DESTRØY	X	X				
EDIT	X	X	X			
EQUIV	X	X		X	X	
RENAME	X	X		X		
SØFPRINT	X	X	X			X

DMAP for Command: MREDUCE

The MREDUCE command performs a modal synthesis reduction for a component substructure. The resulting generalized coordinates for the reduced substructure will consist of selected boundary point displacements and generalized displacements of the modal coordinates. The MRED1 module produces dummy USET and EED data blocks for the execution of the mode extraction procedure. The EQST and DMR data blocks are created for use by the MRED2 module. The MRED2 module performs the actual matrix reduction. Note that, because the number of modal degrees of freedom is a calculated value, the RUN=DRY option is not allowed for modal reduction.

Raw DMAP:

```
1   MRED1     CASECC,GEØM4,DYNAMICS,CSTM/USETR,EEDR,EQST,DMR/*NAMEA   */
2             S,N,DRY/STP/S,N,NØFIX/S,N,SKIPM/*REAL* $
3   CØND      LBM3STP,DRY $
4   SØFI      /KNØA,MNØA,PNØA,BNØA,K4NØA/S,N,DRY/*NAMEA   */*KMTX*/*MMTX*/
5             *PVEC*/*BMTX*/*K4MX* $
6   CØND      LBM2STP,SKIPM $
7   EQUIV     KNØA,KFFX/NØFIX $   (K only)
8   EQUIV     MNØA,MFFX/NØFIX $   (M only)
9   EQUIV     BNØA,BFFX/NØFIX $   (B only)
10  EQUIV     K4NØA,K4FFX/NØFIX $   (K4 only)
11  CØND      LBM1STP,NØFIX $
12  SCE1      USETR,KNØA,MNØA,BNØA,K4NØA/KFFX,KFSX,KSSX,MFFX,BFFX,K4FFX $
13  LABEL     LBM1STP $
14  READ      KFFX,MFFX,BFFX,K4FFX,EEDR,USETR,/LAMAR,PHIR,MIR,ØEIGR/*MØDES*/
15            NEIGVS $
16  ØFP       LAMAR,ØEIGR,,,,// $
17  EQUIV     PHIR,PHIS/NØFIX $
18  CØND      LBM2STP,NØFIX $
19  UMERGE    USETR,PHIR,/PHIS/*N*/*F*/*S* $
20  LABEL     LBM2STP $
21  MRED2     CASECC,LAMAR,PHIS,EQST,USETR,KNØA,MNØA,BNØA,K4NØA,PNØA,DMR,
22            QSM/KNØB,MNØB,BNØB,K4NØB,PNØB,PØNØB/STP/S,N,DRY/*PVEC* $
23  LABEL     LBM3STP $
24  LØDAPP    PNØB,PØNØB//*NAMEB   */S,N,DRY $   (PA only)
25  CØND      FINIS,DRY $
```

(Remove for PA)

Variables:

STP	= Step number
PVEC	= PVEC for option P, PAPP for option PA
NAMEA	= Name of input substructure , A
NAMEB	= Name of output substructure , B
NØA	= Internal number of substructure A
NØB	= Internal number of substructure B
KFFX,KFSX,KSSX	= K only
MFFX	= M only
BFFX	= B only
K4FFX	= K4 only
LAMAR,PHIS	= Remove for option PA
QSM	= Remove for R.F. 9

DMAP for Substructure Plots: PLØT

Any level of substructure may be plotted as an undeformed shape using the existing NASTRAN plot logic. The plot sets generated in Phase 1 are combined and transformed for that plotting.

Raw DMAP:

```
1   PLTMRG      CASECC,PCDB/PLTSTP,GPSTP,ELSTP,BGSTP,CASSTP,EQSTP/*NAME    */
2               S,N,NGP/S,N,LSIL/S,N,NPSET $
3   SETVAL      //S,N,PLTFLG/1/S,N,PFIL/0 $
4   PLØT        PLTSTP,GPSTP,ELSTP,CASSTP,BGSTP,EQSTP,,,,,/PMSTP/NGP/LSIL/
5               S,N,NPSET/S,N,PLTFLG/S,N,PFIL $
6   PRTMSG      PMSTP// $
```

Variables:

NAME	= Name of substructure to be plotted
STP	= Step number

DMAP for Commands: RECØVER (Phase 2), MRECØVER (Phase 1, 2)

RECØVER performs the recovery and output of the Phase 2 solution data. MRECOVER performs the recovery and output subsequent to a Phase 1 or 2 MREDUCE or CREDUCE operation. The NASTRAN solution displacement vector (either displacement vectors or eigenvectors) is transformed and expanded to correspond to the degrees of freedom of the selected component substructures. Each pass through the DMAP loop corresponds to a requested structure to be processed. The RCØVR module selects the substructure to be processed with the loop counter, ILØØP.

Raw DMAP:

```
1   FILE      U1=APPEND/U2=APPEND/U3=APPEND/U4=APPEND/U5=APPEND $
2   PARAM     //*ADD*/ILØØP/0/0 $
3   LABEL     LBSTP $
4   RCØVR     CASESS,GEØM4,KGG,MGG,PGG,UGV,DIT,DLT,BGG,K4GG,PPF/ØUGV1
5             ØPG1,ØQG1,U1,U2,U3,U4,U5/S,N,DRY/S,N,ILØØP/STP/*NAMEFSS */
6             NSØL/NEIGV/S,N,LUI/S,N,U1N/S,N,U2N/S,N,U3N/S,N,U4N/S,N,U5N/
7             S,N,NØSØRT2/V,Y,UTHRESH/V,Y,PTHRESH/V,Y,QTHRESH $
8   EQUIV     ØUGV1 ,ØUGV /NØSØRT2/ØQG1,ØQG/NØSØRT2 $
9   EQUIV     ØPG1,ØPG/NØSØRT2 $   (R.F. 1, 2, 8, or 9 only)
10  CØND      NST2STP,NØSORT2 $
11  SDR3      ØUGV1 ,ØPG1,ØQG1,,,/ØUGV ,ØPG,ØQG,,, $
12  LABEL     NST2STP $
13  ØFP       ØUGV ,ØPG,ØQG,,,//S,N,CARDNØ $
14  CØND      LBBSTP,ILØØP $
15  REPT      LBSTP,100 $
16  LABEL     LBBSTP $
17  SØFØ      ,U1,U2,U3,U4,U5//-1/*XXXXXXXX* $
```

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY.

Variables:

KGG = K option only
MGG = M option only
BGG = B option only
K4GG = K4 option only

R.F.	1	2	3	8	9
GEØM4 =	GEØM4	GEØM4	LAMA	GEØM4	GEØM4
PGG =	PGG	PGG		PPF	PPT
UGV =	UGV	UGV	PHIG	UGV	UGV
PPF =				PPF	TØL
ØUGV1 =	ØUGV1	ØUGV1	ØPHIG1	ØUGV1	ØUGV1
ØUGV =	ØUGV	ØUGV	ØPHIG	ØUGV	ØUGV

SS = SS or CC (if after SØLVE step)
DIT,DLT = Remove if not R.F. 1, 2, or 3
ØPG1,ØPG = Remove if R.F. 3
NSØL = Rigid Format solution number
NEIGV = R.F. 3 only
NAMEFSS = Name of solution structure

DMAP for Command: REDUCE

The REDUCE command initiates the matrix partitioning operations to be performed on the stiffness, mass, damping, and load vectors in order to produce a set of matrices defined by a subset of the original degrees of freedom. The REDUCE module generates the partitioning vector PV, a USET data block US, and an identity matrix IN from the bulk data and the corresponding substructure tables stored on the SØF. The remainder of the DMAP sequence directs the actual matrix operations.

Raw DMAP:

```
1   REDUCE    CASECC,GEØM4/PVNØA,USSTP,INSTP/STP/S,N,DRY/*PVEC* $
2   CØND      LBRSTP,DRY $
3   SØFI      /KNØA,MNØA,PNØA,BNØA,K4NØA/S,N,DRY/*NAMEOOOA*/*KMTX*/*MMTX*/
4             *PVEC*/*BMTX*/*K4MX* $
5   CØND      LBRSTP,DRY $
6   SMP1      USSTP,KNØA,,,/GØNØA,KNØB,KØNØA,LØNØA,,,,, $          }
7   MERGE     GØNØA,INSTP,,,,PVNØA/GNØA/1/TYP/2 $                  } (K only)
8   SØFØ      ,GNØA,LONØA,,,//DRY/*NAMEOOOA*/*HØRG*/*LMTX* $       }
9   SØFØ      ,KNØB,,,,//DRY/*NAMEOOOB*/*KMTX* $
10  SØFI      /GNØA,,,,/S,N,DRY/*NAMEOOOA*/*HØRG* $   (all except K)
11  MPY3      GNØA,MNØA,/MNØB/0/0 $                                 } (M only)
12  SØFØ      ,MNØB,,,,//DRY/*NAMEOOOB*/*MMTX* $                    }
13  MPY3      GNØA,BNØA,/BNØB/0/0 $                                 } (B only)
14  SØFØ      ,BNØB,,,,//DRY/*NAMEOOOB*/*BMTX* $                    }
15  MPY3      GNØA,K4NØA,/K4NØB/0/0 $                               } (K4 only)
16  SØFØ      ,K4NØB,,,,//DRY/*NAMEOOOB*/*K4MX* $                   }
17  PARTN     PNØA,,PVNØA/PØNØA,,,/1/1/2 $                          }
18  MPYAD     GNØA,PNØA,/PNØB/1/1/0/1 $                             } (P or PA only)
19  SØFØ      ,PØNØA,,,,//DRY/*NAMEOOOA*/*PØVE* $                   }
20  SØFØ      ,PVNØA,,,,//DRY/*NAMEOOOA*/*UPRT* $
21  SØFØ      ,PNØB,,,,//DRY/*NAMEOOOB*/*PVEC* $   (P or PA only)
22  LABEL     LBRSTP $
23  LØDAPP    PNØB,PØNØA//*NAMEOOOB*/S,N,DRY $   (PA only)
```

Variables:

STP	= Step number
NAMEOOOA	= Name of input structure, A
NAMEOOOB	= Name of output structure, B
NØA,NØB	= Internal numbers of substructures A and B
TYP	= Matrix precision flag (1 = single)
PVEC	= PVEC for P option, PAPP for PA option
PØVE	= PØVE for P option, PØAP for PA option

DMAP for Command: RUN

The RUN command defines the DRY parameter for use by the subsequent DMAP instructions. If the user specifies RUN=DRYGØ, a special set of DMAP instructions are placed at the end of the entire command sequence.

Raw DMAP:

```
PARAM       //*ADD*/DRY/I  /0$
```

Variables:

I = Integer code for RUN option (DRY = -1, GØ = 0, STEP = 1)

If RUN=DRYGØ, I is set to (DRY) initially and the following DMAP is inserted at the end of the complete ALTER stream:

```
LABEL       LBSEND $
PARAM       //*ADD*/DRY/DRY/1 $
CØND        FINIS,DRY $
REPT        LBSBEG,1 $
JUMP        FINIS $
```

DMAP for External I/Ø Commands: SØFIN, SØFØUT, RESTØRE, DUMP, DHECK

Several operations may be performed on the NASTRAN user files and the SØF file using the EXIØ module. The various input parameters are set by the Substructure Commands.

Raw DMAP:

```
EXIØ        //S,N,DRY/MACH/*DEVI*/*UNITNAME*/*FØRM*/*MØDE*/*PØSI*/*ITEM*/
            *NAME0001*/*NAME0002*/*NAME0003*/*NAME0004*/*NAME0005* $
```

Variables:

MØDE	= First four characters of command name (i.e., 'SØFI', 'REST')
DEVI	= Device used for I/Ø file ('TAPE' or 'DISK')
UNITNAME	= Name of NASTRAN user file assigned to I/Ø file (i.e., INPT, INP1, etc.)
FØRM	= Format of data ('EXTE' or 'INTE')
PØSI	= Position of file on device ('REWI', 'NØRE', or 'EØF')
ITEM	= Name of SØF item or 'ALL', 'MATR', 'TABL', or 'PHAS'
NAME0001, etc.	= Names of substructures to be copied

The following chart describes the variables used for each command:

Command	MØDE	DEVI	UNITNAME	FØRM	PØSI	ITEM	$NAME0000_i$
SØFIN	X	X	X	X	X	X	X
SØFØUT	X	X	X	X	X	X	X
RESTØRE	X	X	X				
DUMP	X	X	X				
CHECK	X	X	X				

DMAP for Command: SØLVE

The SØLVE command provides the necessary data for execution of the solution phase of NASTRAN. Module SGEN replaces the NASTRAN GP1 module for the purpose of defining an equivalent pseudostructure from data blocks. The new data blocks GE3S and GE4S contain the load and constraint data in the form of converted bulk data card images. The stiffness, mass, viscous damping, and structural damping matrices are obtained from the SØF files and added to any user matrix terms. The static and dynamic analysis rigid formats require separate raw DMAP. Both sets of raw DMAP are shown below.

Raw DMAP, Rigid Formats 1-3

```
1   ALTER       (Remove GP1)
2   PARAM       //*NØP*/ALWAYS=-1 $
3   SGEN        CASECC,GEØM3,GEØM4,DYNAMICS/CASESS,CASEI,GPL,EQUEXIN,GPDT,
4               BGPDT,SIL,GE3S,GE4S,DYNS/S,N,DRY/*NAMESØLS*/S,N,LUSET/
5               S,N,NØGPDT $
6   PURGE       CSTM $
7   EQUIV       GE3S,GEØM3/ALWAYS/GE4S,GEØM4/ALWAYS/CASEI,CASECC/ALWAYS/
8               DYNS,DYNAMICS/ALWAYS $
9   CØND        LBSTP,DRY $
10  ALTER       (Remove PLØT)
11  ALTER       (Remove NØSIMP CØND)
12  CØND        LBSØL,NØSIMP $
13  ALTER       (Remove Property Øptimization EQUIV or NØMGG CØND)
14  CØND        LBSØL,NØMGG $
15  ALTER       (Remove SMA3)
16  LABEL       LBSØL $
17  SØFI        /KNØS,MNØS,,,/DR/*NAMESØLS*/*KMTX*/*MMTX* $
18  EQUIV       KNØS,KGG/NØSIMP $   (K only)
19  EQUIV       MNØS,MGG/NØSIMP $   (M only)
20  CØND        LBSTP,NØSIMP $
21  ADD         KGGX,KNØS/KGG $   (K only)
22  ADD         MGG,MNØS/MGGX $   (M only)
23  EQUIV       MGGX,MGG/ALWAYS $
24  LABEL       LBSTP $
25  CHKPNT      MGG $
26  ALTER       (After GP4)
27  CØND        LBSEND,DRY $
28  ALTER       (Remove SDR2 - PLØT)
```

Variables:

NAMESØLS = Name of solution structure
NØS = Internal number of solution structure
STP = Step number

Raw DMAP, Rigid Formats 8, 9

```
1   ALTER    (Remove GP1)
2   PARAM    //*NØP*/ALWAYS=-1 $
3   SGEN     CASECC,GEØM3,GEØM4,DYNAMICS/CASESS,CASEI,GPL,EQEXIN,GPDT,
4            BGPDT,SIL,GE3S,GE4S,DYNS/S,N,DRY/*NAMESØLS*/S,N,LUSET/
5            S,N,NØGPDT $
6   PURGE    CSTM $
7   EQUIV    GE3S,GEØM3/ALWAYS/GE4S,GEØM4/ALWAYS/CASEI,CASECC/ALWAYS
8            DYNS,DYNAMICS/ALWAYS $
9   CØND     LBSTP,DRY $
10  ALTER    (Remove PLØT)
11  ALTER    (Remove NØSIMP PURGE and CØND)
12  ALTER    (Remove GPWG and SMA3)
13  SØFI     /KNØS,MNØS,BNØS,K4NØS,/DRY/*NAMESØLS*/*KMTX*/*MMTX*/*BMTX*/
14           *K4MX* $
15  EQUIV    KNØS,KGG/NØKGGX $        }
16  CØND     LB2K,NØKGGX $            }  (K only)
17  ADD      KGGX,KNØS/KGG $          }
18  LABEL    LB2K $                   }
19  EQUIV    MNØS,MGG/NØMGG $         }
20  CØND     LB2M,NØMGG $             }
21  ADD      MGG,MNØS/MGGX $          }  (M only)
22  EQUIV    MGGX,MGG/ALWAYS $        }
23  LABEL    LB2M $                   }
24  EQUIV    BNØS,BGG/NØBGG $         }
25  CØND     LB2B,NØBGG $             }
26  ADD      BGG,BNØS/BGGX $          }  (B only)
27  EQUIV    BGGX,BGG/ALWAYS $        }
28  LABEL    LB2B $                   }
29  EQUIV    K4NOS,K4GG/NØK4GG $      }
30  CØND     LB2K4,NØK4GG $           }
31  ADD      K4GG,K4NØS/K4GGX $       }  (K4 only)
32  EQUIV    K4GGX,K4GG/ALWAYS $      }
33  LABEL    LB2K4 $                  }
34  LABEL    LBSTP $
35  CHKPNT   MGG,BGG,K4GG $
```

Raw DMAP, Rigid Formats 8, 9 (continued)

```
36  ALTER     (Remove MDEMA, KDEK2 PARAM)
37  PARAM     //*AND*/MDEMA/NØUE/NØM2PP $
38  PARAM     //*ADD*/KDEK2/1/0 $   (K only)
39  PARAM     //*ADD*/NØMGG/1/0 $   (M only)
40  PARAM     //*ADD*/NØBGG/1/0 $   (B only)
41  PARAM     //*ADD*/NØK4GG/1/0 $   (K4 only)
42  ALTER     (Remove NØSIMP, NØGPDT EQUIV)
43  EQUIV     K2DD,KDD/KDEK2 $
44  EQUIV     M2DD,MDD/NØMGG $
45  EQUIV     B2DD,BDD/NØBGG $
46  ALTER     (Remove SDR2 and PLØT)
47  EQUIV     UPVF,UPVC/NØA $
48  CØND      LBL19,NØA $
49  SDR1      USETD,,UDVF,,,GØD,GMD,,,,/UPVC,,/1/DYNAMICS $
50  LABEL     LBL19 $
51  CHKPNT    UPVC $
52  EQUIV     UPVC,UGV/NØUE $
53  CØND      LBUE,NØUE $
54  UPARTN    USET,UPVC/UGV,UEV,,/*P*/*G*/*E* $
55  LABEL     LBUE $
```

Variables:

NAMESØLS	= Name of solution structure
NØS	= Internal number of solution structure
STP	= Step number
UDVF	= UDVF for R.F. 8, UDVT for R.F. 9

DMAP for Command: SUBSTRUCTURE

The SUBSTRUCTURE command is necessary to initiate the automatic DMAP process. In Phase 1, the SUBPH1 module is used to build the substructure tables on the SØF from the NASTRAN grid point tables and the SØFØ module is used to copy the matrices onto the SØF. In Phase 2 and Phase 3, the initial value of the DRY parameter is set and the DMAP sequence is initiated.

Raw DMAP:

PHASE 1

```
1   ALTER     2,0
2   PARAM     //*NØP*/ALWAYS=-1 $
3   SGEN      CASECC,,,/CASESS,CASEI,,,,,,,,/S,N,DRY/*XXXXXXXX*/S,N,LUSET/
4             S,N,NØGPDT $
5   EQUIV     CASEI,CASECC/ALWAYS $
6   ALTER     (After GP4)
7   PARAM     //*ADD*/DRY-1 /0 $
8   LABEL     LBSBEG $
9   CØND      LBLIS,DRY $   (R.F. 1, 2, 3, and 9 only)
10  SSG1      SLT,BGPDT,CSTM,SIL,EST,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/      } (R.F. 9 and P
11            LUSET/NSKIP $                                               } or PA only)
12  CHKPNT    PG $                                                        }
13  ALTER     (Remove DECØMP)
14  SSG2      USET,GM,,KFS,GO,,PG/QR,PØ,PS,PL $                           } (R.F. 9 and P
15  CHKPNT    PØ,PS,PL $                                                  } or PA only)
16  LABEL     LBLIS $   (R.F. 1, 2, 3, and 9 only)
17  ALTER     (Remove solution)
18  SUBPH1    CASECC,EQEXIN,USET,BGPDT,CSTM,GPSETS,ELSETS//S,N,DRY/
19            *NAME    */PLØTID /*PVEC* $
20  CØND      LBSEND,DRY $
21  EQUIV     PG,PL/NØSET $                                               }
22  CØND      LBL10,NØSET $                                               } (R.F. 1, 2, or
23  SSG2      USET,GM,YS,KFS,GØ,,PG/QR,PØ,PS,PL $                         } 3 and P or PA
24  CHKPNT    PØ,PS,PL $                                                  } only)
25  LABEL     LBL10 R                                                     }
26  SØFØ      ,KAA,MAA,PL,BAA,K4AA//S,N,DRY/*NAME*/*KMTX*/*MMTX*/PVEC*/
27            *BMTX*/*K4MX* $
28  LØDAPP    PL,//*NAME    */S,N,DRY $   (R.F. 1, 2, 3, or 9 and PA only)
29  EQUIV     CASESS,CASECC/ALWAYS $
```

PHASE 2

```
1   ALTER       2,0
2   PARAM       //*ADD*/DRY/I/O $
3   LABEL       LBSBEG $
```

PHASE 3

```
1   ALTER       (Remove DECØMP or before dynamic solution)
2   PARAM       //*ADD*/DRY/I/O $
3   LABEL       LBSBEG $
```

Variables:

I	= Integer RUN option code (see RUN command)
NAME	= Phase 1 substructure name
PLØTID	= Phase 1 Plot Set ID
KAA,MAA,PL, BAA,K4AA	= Data blocks dependent on ØPTIØN
PVEC	= PVEC for option P, PAPP for option PA

5.10 SUPPLEMENTARY FUNCTIONAL MODULES

Module	Basic Function	Page
EMA1	Alternative Element Matrix Generator	5.10-2
GPSPC	Automatically constrain possible stiffness matrix singularities	5.10-5

These modules are fully described in Section 4 of the Programmer's Manual. However since they are not incorporated in any of the Rigid Formats, they are included here for reference purposes. These modules must be altered into the Rigid Format.

I. NAME: EMA1 (Element Matrix Assembler)

II. PURPOSE: This module superimposes matrices corresponding to elements into a structural matrix corresponding to all degrees of freedom at all grid points.

III. DMAP CALLING SEQUENCE:

EMA1 GPECT, {KDICT / MDICT}, {KELM / MELM}, SIL, ECT/ {KGGX / MGG}, GPST/C,N,NØK4/C,N,WTMASS $

IV. INPUT DATA BLOCKS:

GPECT - Grid Point Element Connection Table

KDICT / MDICT - Element Matrix Dictionaries

KELM / MELM - Element Matrix Partitions

SIL - Scalar Index List

ECT - Element Connection Table

V. OUTPUT DATA BLOCKS:

KGGX - Assembled Structural Matrix

MGG - Assembled Mass Matrix

GPST - Grid Point Singularity Table

Note: GPST may be purged.

VI. PARAMETERS:

NØK4 - Input, integer, default = -1. Flag which specifies whether damping factor is to be used in assembling matrix (-1 ignores factor).

WTMASS - Input, real, default = 1.0. Constant by which all element matrix terms are multiplied.

VII. EXAMPLE:

To replace module EMA with module EMA1 in Static Analysis (Rigid Format 1) the following alters must be made:

```
ALTER 46, 46  $  STRUCTURAL MATRIX
EMA1      GPECT,KDICT,KELM,SIL,ECT/KGGX,GPST  $
ALTER 50, 50  $  MASS MATRIX
EMA1      GPECT,MDICT,MELM,SIL,ECT/MGG,/C,N,-1/C,Y,WTMASS=1.0 $
ENDALTER  $
```

INFORMATION PREVIOUSLY ON THIS PAGE HAS BEEN DELETED

INFORMATION PREVIOUSLY ON THIS PAGE HAS BEEN DELETED

613 *** USER FATAL MESSAGE 613, THE ABØVE SET CØNTAINS 'EXCEPT' WHICH IS NØT PRECEDED BY 'THRU'.

Only identification numbers included in THRU statements may be excepted. Simplify your SET request.

614 *** USER FATAL MESSAGE 614, THE ABØVE SET IS BADLY SPECIFIED.

The grammar of the SET list is so confused that IFP1 cannot continue. Simplify the SET list.

615 *** USER FATAL MESSAGE 615, AN IMPRØPER ØR NØ NAME GIVEN TØ THE ABØVE SET.

SET lists must have integer names. This SET list does not have one. SET 10 = is the correct format. Give the SET a correct integer name.

616 *** USER FATAL MESSAGE 616, 'EXCEPT' CANNOT BE FØLLØWED BY 'THRU'. LIST EXPLICITLY ALL EXCEPTIØNS.

EXCEPT in SET list can only be followed by integers. An integer larger than THRU pair terminates THRU. Either list exceptions explicitly, use 2 'THRU's or terminate first THRU.

617 *** USER FATAL MESSAGE 617, A NØNPØSITIVE INTEGER APPEARS IN A PØSITIVE PØSITIØN.

Most integer values in case control must be positive. The above card either has a negative integer or a BCD value in a positive position. Check the Case Control Deck documentation in Section 2.3 of the User's Manual for the proper card format.

618 *** USER FATAL MESSAGE 618, PLØTTER ØUTPUT IS REQUESTED BUT NØ PLØT TAPE IS SET UP.

Neither PLT1 or PLT2 is a physical tape. Remove the plot control packet or set up the appropriate tape.

619 *** USER WARNING MESSAGE 619, SET MEMBER *** BELØNGS TØ *** THRU ***.

A set member is already included in a THRU. The individual member will be absorbed in the THRU.

620 *** USER WARNING MESSAGE 620, DUPLICATE *** IS IN SET LIST.

A set member is listed twice. The second reference will be deleted.

621 *** USER WARNING MESSAGE 621, INTERVAL *** THRU *** ØVERLAPS INTERVAL *** THRU ***. THE MAXIMUM INTERVAL WILL BE USED.

625 *** USER FATAL MESSAGE 625, TØØ LARGE ID ØN PRECEDING SUBCASE TYPE CARD. ALL ID'S MUST BE LESS THAN 99,999,999.

Reduce the size of your subcase identification number. Note also that BCD subcase identification numbers are not legal.

626 *** USER FATAL MESSAGE 626, SUBCØM SUBCASE DØES NØT HAVE A SUBSEQ CARD.

A SUBCØM SUBCASE must contain a SUBSEQ card to define the linear combination coefficients.

627 *** USER FATAL MESSAGE 627, THE ABØVE SUBCASE HAS BØTH A STATIC LØAD AND A REAL EIGENVALUE METHØD SELECTIØN -- REMØVE ØNE.

Rigid Formats 5 and 13 require a static load and method selection in the Case Control Deck. Both a load and a method selection cannot take place in the same subcase. See Sections 3.6.4 and 3.14.4, respectively, for subcase requirements.

628 *** USER FATAL MESSAGE 628, THERMAL, DEFØRMATIØN, AND EXTERNAL LØADS CANNØT HAVE THE SAME SET IDENTIFICATIØN NUMBER.

Set id's specified on the LØAD, TEMP (LØAD), and DEFØRM Case Control Cards must be unique.

629 *** USER WARNING MESSAGE 629, ECHØ CARD HAS REPEATED ØR UNRECØGNIZABLE SPECIFICATIØN DATA-REPEATED SPECIFICATIØNS WILL BE IGNØRED, UNRECØGNIZABLE SPECIFICATIØNS WILL BE TREATED AS SØRT.

630 *** USER WARNING MESSAGE 630, ECHØ CARD WITH -NØNE- SPECIFICATIØN HAS ADDITIØNAL SPECIFICATIØNS WHICH WILL BE IGNØRED.

675 *** USER FATAL MESSAGE 675, ABØVE CARD DØES NØT BEGIN WITH A NØNNUMERIC WØRD.

676 *** USER FATAL MESSAGE 676, **** IS NØT RECØGNIZED ØN ABØVE CARD.

677 *** USER FATAL MESSAGE 677, ILLEGAL VALUE SPECIFIED.

678 *** USER FATAL MESSAGE 678, *** CØNTRADICTS PREVIOUS DEFINITIØN.

679 *** USER FATAL MESSAGE 679, *** DELIMETER ILLEGALLY USED.

680 *** USER FATAL MESSAGE 680, **** ILLEGAL IN STATEMENT.

681 *** USER FATAL MESSAGE 681, **** IS ILLEGAL IN STATEMENT.

682 *** USER FATAL MESSAGE 682, **** IS ILLEGAL IN STATEMENT.

683 *** USER FATAL MESSAGE 683, TØØ MANY SUBCASES. MAXIMUM = 200 ØN ANY ØNE XY-ØUTPUT CØMMAND CARD.

684 *** USER FATAL MESSAGE 684, SUBCASE-ID IS LESS THAN 1 ØR IS NØT IN ASCENDING ØRDER.

685 *** USER FATAL MESSAGE 685, **** = PØINT ØR ELEMENT ID IS ILLEGAL (LESS THAN 1).

686 *** USER FATAL MESSAGE 686, NEGATIVE ØR ZERØ CØMPØNENTS ARE ILLEGAL.

687 *** USER FATAL MESSAGE 687, ALPHA-CØMPØNENTS ARE NØT PERMITTED FØR STRESS ØR FØRCE XY-ØUTPUT REQUESTS.

An XYPLØT command for stresses and forces cannot have alphabetic characters in the item code. See the tables in Section 4.3.3 for the proper format.

2068 *** USER FATAL MESSAGE 2068, UNDEFINED GRID PØINT **** IN TRANSFER FUNCTIØN SET ****.

2069 *** USER FATAL MESSAGE 2069, UNDEFINED GRID PØINT **** IN TRANSIENT INITIAL CØNDITION SET ****.

2070 *** USER FATAL MESSAGE 2070, REQUESTED DMIG MATRIX **** IS UNDEFINED.

2071 *** USER FATAL MESSAGE 2071, DYNAMIC LØAD SET ******** REFERENCES UNDEFINED ******** SET ********.

This message is issued when DAREA, DELAY, or DPHASE set IDs are referenced on a TLØADi or RLØADi card but are not defined.

2072 *** SYSTEM WARNING MESSAGE 2072, CARD TYPE *** NØT FØUND ØN DATA BLØCK.

This warning message is issued when the trailer bit for the card type = 1 but the corresponding record is not on the data block.

2073 *** USER INFØRMATIØN MESSAGE 2073, MPYAD METHØD = ****, NØ. ØF PASSES = ****.

This message gives the method selected and number of passes required.

2074 *** USER FATAL MESSAGE 2074, UNDEFINED TRANSFER FUNCTIØN SET ****.

2075 *** USER FATAL MESSAGE 2075, IMPRØPER KEYWØRD ******** FØR APPRØACH PARAMETER IN DMAP INSTRUCTIØN.

2076 *** USER WARNING MESSAGE 2076, SDR2 ØUTPUT DATA BLØCK NØ. 1 IS PURGED.

2077 *** USER WARNING MESSAGE 2077, SDR2 ØUTPUT DATA BLØCK NØ. 2 IS PURGED.

2078 *** USER WARNING MESSAGE 2078, SDR2 ØUTPUT DATA BLØCK NØ. 3 IS PURGED.

2079 *** USER WARNING MESSAGE 2079, SDR2 FINDS THE -EDT-, -EST-, ØR -GPTT- PURGED ØR INADEQUATE AND IS THUS NØT PRØCESSING ANY REQUESTS FØR STRESSES ØR FØRCES.

2080 *** USER WARNING MESSAGE 2080, SDR2 ØUTPUT DATA BLØCK NØ. 6 IS PURGED.

2081 *** USER FATAL MESSAGE 2081, NULL DIFFERENTIAL STIFFNESS MATRIX.

Differential stiffness is not defined for all structural elements. Only the following elements are defined for differential stiffness calculations: RØD, TUBE, SHEAR (but not TWIST) panels, triangular and quadrilateral membranes (TRMEM, TRIA2, QDMEM, QUAD2), and BAR. The combination two dimensional elements TRIA1 and QUAD1, are defined only if their membrane thickness is nonzero. The user has not included any of these elements in his model and therefore a null differential stiffness matrix was generated.

2083 *** USER FATAL MESSAGE 2083, NULL DISPLACEMENT VECTØR.

The displacement vector for the linear solution part of a static analysis with differential stiffness problem, or the incremental displacement vector in a piecewise linear analysis rigid format problem is the zero vector. Check loading conditions.

2084 *** SYSTEM FATAL MESSAGE 2084, DSMG2 LØGIC ERRØR ****.

Incompatible input and output pairs in the DMAP calling sequence to module DSMG2. See the module description for DSMG2 in the Programmer's Manual.

2085 *** USER INFØRMATIØN MESSAGE 2085, **** SPILL, NPVT ****.

During processing of the ECPT data block in module ****, so many elements were attached to the referenced pivot point (NPVT) that module spill logic was initiated.

2086 *** USER INFØRMATIØN MESSAGE 2086, SMA2 SPILL, NPVT ****.

See explanation for Message 2085.

2087 *** SYSTEM FATAL MESSAGE 2087, ECPT CØNTAINS BAD DATA.

Use the TABPT module to print the ECPT data block.

2088 *** USER FATAL MESSAGE 2088, DUPLICATE TABLE ID ****.

All tables must have unique numbers. Check for uniqueness.

2089 *** USER FATAL MESSAGE 2089, TABLE **** UNDEFINED.

The table number in the list of table numbers input to subroutine PRETAB via argument 7 was not found after reading the DIT data block. Check list of tables in the Bulk Data Deck.

2090 *** SYSTEM FATAL MESSAGE 2090, TABLE DICTIØNARY ENTRY **** MISSING.

Logic error in subroutine PRETAB, or open core used by PRETAB has been destroyed.

2091 *** SYSTEM FATAL MESSAGE 2091, PLA3, BAD ESTNL EL ID ****.

ESTNL data block is not in expected format. Use TABPT module to print the ESTNL data block.

2092 *** SYSTEM WARNING MESSAGE 2092, SDR2 FINDS A SYMMETRY SEQUENCE LENGTH = **** AND AN INSUFFICIENT NUMBER ØF VECTØRS AVAILABLE = **** WHILE ATTEMPTING TØ CØMPUTE STRESSES AND FORCES. ALL FURTHER STRESS AND FØRCES CØMPUTATIØN TERMINATED.

2093 *** USER FATAL MESSAGE 2093, NØLIN CARD FRØM NØLIN SET **** REFERENCES GRID PØINT **** UD SET.

2094 *** USER WARNING MESSAGE 2094, SUBRØUTINE TABFMT, KEYNAME ******** NØT IN LIST ØF AVAILABLE KEYNAMES. *** LIST ØF RECØGNIZED KEYNAMES FØLLOWS.

The TABPRT Module can only be used to print certain table data blocks. For table data blocks not appearing in the list, use the TABPT Module.

2095 *** USER WARNING MESSAGE 2095, SUBRØUTINE TABFMT, PURGED INPUT.

2096 *** USER WARNING MESSAGE 2096, SUBRØUTINE TABFMT, EØF ENCØUNTERED.

2097 *** USER WARNING MESSAGE 2097, SUBRØUTINE TABFMT, EØR ENCØUNTERED.

2098 *** USER WARNING MESSAGE 2098, SUBRØUTINE TABFMT, INSUFFICIENT CØRE.

2099 *** USER WARNING MESSAGE 2099, SUBRØUTINE TABFMT, KF **********.

2100 *** USER FATAL MESSAGE 2100, TEMPERATURE SPECIFIED AS ******** AND ******** FØR GRID ********.

Conflicting data has been supplied to specify the temperatures at a grid point.

2101A *** USER FATAL MESSAGE 2101A, GRID PØINT **** CØMPØNENT *** ILLEGALLY DEFINED IN SETS ****.

The above grid point and component has been defined in each of the above dependent subsets. A point may belong to at most one dependent subset.

2101B *** USER FATAL MESSAGE 2101B, SCALAR PØINT **** ILLEGALLY DEFINED IN SETS ****.

2102 *** USER WARNING MESSAGE 2102, LEFT-HAND MATRIX RØW PØSITIØN **** ØUT ØF RANGE - IGNØRED.

A term in the A matrix whose row position is larger than the stated dimension was detected and ignored.

2103 *** SYSTEM FATAL MESSAGE 2103, SUBRØUTINE MAT WAS CALLED WITH INFLAG=2, THE SINE ØF ANGLE X, MATERIAL ØRIENTATIØN ANGLE, NØNZERØ, BUT SIN(X)**2+CØS(X)**2 DIFFERED FRØM 1 IN ABSØLUTE VALUE BY MØRE THAN .0001.

A check is made in MAT to insure that ABS(SIN(THETA)**2+CØS(THETA)**2-1.00) .LE. .0001 when INFLAG = 2. The calling routine did not set SINTH and CØSTH cells in /MATIN/ properly.

2104 *** USER FATAL MESSAGE 2104, UNDEFINED CØØRDINATE SYSTEM ****.

See the explanation for Message 2025.

2105 *** USER FATAL MESSAGE 2105, PLØAD2 CARD FRØM LØAD SET **** REFERENCES MISSING ØR NØN-2-D ELEMENT ****.

PLØAD2 cards must reference two-dimensional elements.

2106 *** USER FATAL MESSAGE 2106, LØAD CARD DEFINES NØNUNIQUE LØAD SET ****.

2107 *** USER FATAL MESSAGE 2107, EIG-CARD FRØM SET **** REFERENCES DEPENDENT CØØRDINATE ØR GRID PØINT ****.

When the point option is used on an EIGB, EIGC or EIGR card, the referenced point and component must be in the analysis set for use in normalization.

2108 *** USER FATAL MESSAGE 2108, NØ XY-PLØTTER HAS BEEN SPECIFIED TØ THIS PØINT.

2109 *** USER FATAL MESSAGE 2109, NØ GRID, SCALAR ØR EXTRA PØINTS DEFINED.

2110 *** USER WARNING MESSAGE 2110, INSUFFICIENT CØRE TØ HØLD CØNTENTS ØF GINØ FILE *** FURTHER PRØCESSING ØF THIS DATA BLØCK IS ABANDØNED.

2124 *** USER WARNING MESSAGE 2124, MØDULE VEC - NR=0, ØUTPUT WILL BE PURGED.

2125 *** USER WARNING MESSAGE 2125, MØDULE VEC - NZ=0, ØUTPUT WILL BE PURGED.

2126 *** USER FATAL MESSAGE 2126, UNDEFINED MATERIAL FØR ELEMENT ********.

2127 *** SYSTEM FATAL MESSAGE 2127, PLA2 INPUT DATA BLØCK NØ. **** IS PURGED.

Data blocks DELTAUGV and DELTAPG cannot be purged. See module description for PLA2 in Section 4 of the Programmer's Manual.

2128 *** SYSTEM FATAL MESSAGE 2128, PLA2 ØUTPUT DATA BLØCK NØ. **** IS PURGED.

Data blocks UGV1, PGV1 cannot be purged. See module description for PLA2 in Section 4 of the Programmer's Manual.

2129 *** SYSTEM FATAL MESSAGE 2129, PLA2, ZERØ VECTØR ØN APPENDED DATA BLØCK NØ. ****.

Zero displacement vector found on UGV1 data block output from PLA2. Possible system failure.

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY.

2130 *** USER FATAL MESSAGE 2130, ZERØ INCREMENTAL DISPLACEMENT VECTØR NØT ADMISSIBLE AS INPUT TØ MØDULE PLA2.

See discussion of the Piecewise Linear Analysis rigid format.

2131 *** USER FATAL MESSAGE 2131, NØN-SCALAR ELEMENT *** REFERENCES A SCALAR PØINT.

An element which must be attached to a geometric grid point has been attached to a scalar point. No geometry data can be inferred.

2132 *** USER FATAL MESSAGE 2132, NØN-ZERØ SINGLE PØINT CONSTRAINT VALUE SPECIFIED BUT DATA BLØCK YS IS PURGED.

Many rigid formats do not support constrained displacements (especially dynamic solutions). An attempt to specify a constrained displacement in these cases results in this message.

2133 *** USER FATAL MESSAGE 2133, INITIAL CØNDITIØN IN SET **** SPECIFIED FØR PØINT NØT IN ANALYSIS SET.

Initial conditions can only be specified for analysis set points. Therefore the point/component mentioned on TIC cards must belong to the D or H sets.

2134 *** USER FATAL MESSAGE 2134, LØAD SET *** DEFINED FØR BØTH GRAVITY AND NØN-GRAVITY LØADS.

The same load set identification number cannot appear on both a GRAV card and another loading card such as FØRCE or MØMENT. To apply both a gravity load and a concentrated load simultaneously the LØAD card must be used.

2135 *** USER FATAL MESSAGE 2135, DLØAD CARD *** HAS A DUPLICATE SET ID FOR SET ID ***.

The Li set ID's on a DLØAD card are not unique. See DLØAD card description in the User's Manual.

2136 *** USER FATAL MESSAGE 2136, SET ID *** HAS BEEN DUPLICATED ØN A DLØAD, RLØAD1,2 or TLØAD1,2 CARD.

All dynamic load set ID's must be unique.

2137 *** USER FATAL MESSAGE 2137, PRØGRAM RESTRICTIØN FØR MØDULE SSG1 - ØNLY 100 LØAD SET ID'S ALLØWED. DATA CØNTAINS **** LØAD SET ID'S.

Reduce the number of Load Set ID's.

2138 *** USER FATAL MESSAGE 2138, ELEMENT IDENTIFICATION NUMBER **** IS TØØ LARGE.

Element identification numbers (on connection cards) must be less than 16,777,215.

2139 *** USER FATAL MESSAGE 2139, ELEMENT **** IN DEFØRM SET **** IS UNDEFINED.

A selected element deformation set includes an element twice, includes a non-existent element, or includes a non-one-dimensional element.

2140 *** USER FATAL MESSAGE 2140, GRID PØINT ØR SCALAR PØINT ID *** IS TØØ LARGE.

Program restriction on the size of integer numbers. A card defining a grid point or scalar point has a number larger than 2,000,000.

2141 *** USER FATAL MESSAGE 2141, MØDULE VEC - EØF ENCØUNTERED WHILE READING GINØ FILE **** DATA BLØCK ********.

2142 *** USER FATAL MESSAGE 2142, INSUFFICIENT CØRE FØR MØDULE VEC. AVAILABLE CØRE = ********** WØRDS. ADDITIONAL CØRE NEEDED = ********** WØRDS.

2143 *** USER FATAL MESSAGE 2143, MØDULE VEC UNABLE TØ IDENTIFY SET ØR SUBSET DESCRIPTØR ********.

2145 *** USER FATAL MESSAGE 2145, ******** FATAL MESSAGES HAVE BEEN GENERATED IN SUBRØUTINE VEC. ØNLY THE FIRST **** HAVE BEEN PRINTED.

2146 *** USER FATAL MESSAGE 2146, BØTH ØF THE SECØND AND THIRD VEC PARAMETERS REQUEST CØMPLEMENT.

2147 *** SYSTEM FATAL MESSAGE 2147, ILLEGAL ELEMENT TYPE = ********** ENCØUNTERED BY DSMG MØDULE.

2150 *** USER FATAL MESSAGE 2150, ILLEGAL VALUE FØR FØURTH PARAMETER = **********.

2151 *** USER WARNING MESSAGE 2151, -PLAARY- ARRAY IS SMALLER THAN MAXIMUM NUMBER ØF ELEMENT TYPES.

2152 *** USER FATAL MESSAGE 2152, GRID PØINT ******** CØMPØNENT ** DUPLICATELY DEFINED IN THE **** SET.

2153 *** USER FATAL MESSAGE 2153, SCALAR PØINT ******** DUPLICATELY DEFINED IN THE **** SET.

2154 *** USER WARNING MESSAGE 2154, ZERØ AREA ØR ILLEGAL CØNNECTIØN FØR HBDY ELEMENT NUMBER ********.

2155 *** USER WARNING MESSAGE 2155, MAT4 AND MAT5 MATERIAL DATA CARDS HAVE SAME ID = ********** MAT4 DATA WILL BE SUPPLIED WHEN CALLED FØR THIS ID.

2156 *** SYSTEM FATAL MESSAGE 2156, ILLEGAL INFLAG = ********** RECEIVED BY HMAT.

2157 *** USER FATAL MESSAGE 2157, MATERIAL ID = ********** DØES NØT APPEAR ØN ANY MAT4 ØR MAT5 MATERIAL DATA CARD.

2158 *** SYSTEM WARNING MESSAGE 2158, A TRAPRG ELEMENT = ********** DØES NØT HAVE SIDE 1-2 PARALLEL TØ SIDE 3-4.

2159 *** USER FATAL MESSAGE 2159, TRIRG ØR TRAPRG ELEMENT = ********** PØSSESSES ILLEGAL GEØMETRY.

2193 *** USER FATAL MESSAGE 2193, A REDUNDANT SET ØF RIGID BØDY MØDES WAS SPECIFIED FØR THE GENERAL ELEMENT.

Only a non-redundant list of rigid body modes is allowed to appear in the u_d set when the S matrix is to be internally calculated in subroutine TA1CA.

2194 *** USER FATAL MESSAGE 2194, A MATRIX D IS SINGULAR IN SUBRØUTINE TA1CA.

While attempting to calculate the [S] matrix for a general element in TA1CA, it was discovered that the matrix D_d which relates $\{u_b\}$ to $\{u_d\}$ was singular and could not be inverted.

2195 *** USER WARNING MESSAGE 2195, ILLEGAL VALUE FØR P4 = ******.

2196 *** USER WARNING MESSAGE 2196, DUMMY SUBRØUTINE TIMTS3.
DUMMY SUBRØUTINE TIMTS4.
DUMMY SUBRØUTINE TIMTS5.

2197 *** SYSTEM FATAL MESSAGE 2197, ABØRT CALLED DURING TIME TEST ØF *********.

2198 *** SYSTEM FATAL MESSAGE 2198, INPUT DATA BLØCK, ******** HAS BEEN PURGED.

2199 *** SYSTEM FATAL MESSAGE 2199, SUMMARY/ ØNE ØR MØRE ØF THE ABØVE FATAL ERRØRS WAS ENCØUNTERED IN SUBRØUTINE ********.

2200 *** USER FATAL MESSAGE 2200. INCØNSISTENT RIGID BØDY SYSTEM.

2251 *** USER WARNING MESSAGE 2251, PHYSICALLY UNREALISTIC VALUE FØR NU ØN MAT1 CARD ********.
VALUE = **********.

2257 *** USER WARNING MESSAGE 2257, SET *** REFERENCED ØN SPLINE CARD **** IS EMPTY.

While processing the SET1 or SET2 card referenced on the SPLINEi card, no included grid points were found. If SET1 was used, either no points were included or they were all scalar points. If SET2 was used, the volume of space referenced did not include any structural grid points. This may occur if a tapered element is extended too far. The spline is omitted from the problem and processing continues.

2258 *** USER FATAL MESSAGE 2258, SET **** REFERENCED ØN SPLINE CARD **** NØT FØUND ØR IT IS EMPTY.

The necessary SET1 or SET2 card was not found or was empty. Include the proper set card or, if it is already included, make sure that the set is not empty. (See description under User Warning Message 2257 shown above).

2259 *** SYSTEM FATAL MESSAGE 2259, PØINT ASSIGNED TØ BØX **** FØR CAERØ* **** NØT IN EQAERØ.

No internal k point could be found for external box. If box number is okay, module APD is in error; if box number is bad, module GI is in error.

2260 *** USER FATAL MESSAGE 2260, SINGULAR MATRIX DEVELØPED WHILE PRØCESSING SPLINE ****

Matrix developed by SSPLIN or LSPLIN (depending on type of spline) could not be inverted; possibly for the Surface Spline all points lie in a straight line, or not enough points are included.

2321 *** USER FATAL MESSAGE 2321, NØ FLUTTER CARDS FØUND.

Flutter analysis requires at least one FLUTTER card.

2322 *** USER FATAL MESSAGE 2322, NEITHER MKAERØ1 ØR MKAERØ2 CARDS FØUND.

Either MKAERØ1 or MKAERØ2 cards are required.

2323 *** USER FATAL MESSAGE 2323, PAERØ* CARD NØ. ******** REFERENCED BY CAERØ* CARD NØ. ******** BUT DØES NØT EXIST.

CAERØi card points to missing PAERØi card.

2324 *** USER FATAL MESSAGE 2324, CAERØ* ELEMENT NØ. ******** REFERENCED ØN A SPLINE* CARD DØES NØT EXIST.

Either a SPLINE1, a SPLINE2, or a SPLINE3 card references a CAERØi card which is missing.

2325 *** USER FATAL MESSAGE 2325, CAERØ* ELEMENT NØ. ******** REFERENCED ØN A SET2 CARD DØES NØT EXIST.

A SET2 card points to a CAERØi which was not included.

2326 *** USER FATAL MESSAGE 2326, CAERØ* ELEMENT NØ. ******** REFERENCES AEFACT CARD NØ. ******** WHICH DØES NØT EXIST.

The listed CAERØi card requires one AEFACT card for LSPAN.

2327 *** USER FATAL MESSAGE 2327, CAERØ* ELEMENT NØ. ******** REFERENCES AEFACT CARD NØ. ******** WHICH DØES NØT EXIST.

The listed CAERØi card requires one AEFACT card for LCHØRD.

2328 *** USER FATAL MESSAGE 2328, SET* AND SPLINE* CARDS REQUIRED.

At least one SET1 or SET2 card and at least one SPLINE1, SPLINE2, or SPLINE3 care required.

2329 *** USER FATAL MESSAGE 2329, DUPLICATE EXTERNAL ID NØ. ******** GENERATED.

The external IDs assigned to each generated box must be unique.

2330 *** USER FATAL MESSAGE 2330, SET1 ØR SPLINE3 CARD NØ. ******** REFERENCES EXTERNAL ID NØ. ******** WHICH DØES NØT EXIST.

External grid point IDs referenced on a SET1 or SPLINE3 card do not exist as structural grid points.

2331 *** USER FATAL MESSAGE 2331, BØX PICKED ØN SPLINE CARD NØ. ******** NØT GENERATED BY CAERØ CARD NØ. ********.

SPLINE card ******** points to a box which was not generated by the CAERØi card.

2332 *** USER WARNING MESSAGE 2332, INVALID INPUT DATA DETECTED IN DATA BLØCK, ****, PRØCESSING STØPPED FØR THIS DATA BLØCK.

2333 *** SYSTEM INFØRMATIØN MESSAGE 2333, MØDULE DDRMM TERMINATED WITH VARIABLE IERRØR = **********.

2334 *** SYSTEM WARNING MESSAGE 2334, ILLEGAL MAJØR ØR MINØR ØFP-ID IDENTIFICATIØNS = *********
********** DETECTED IN DATA BLØCK, ****, PRØCESSING ØF SAID DATA BLØCK DISCØNTINUED.

2335 *** SYSTEM WARNING MESSAGE 2335, THE AMØUNT ØF DATA IS NØT CØNSISTENT FØR EACH EIGENVALUE IN
DATA BLØCK **** PRØCESSING ØF THIS DATA BLØCK TERMINATED.

2336 *** SYSTEM WARNING MESSAGE 2336, A CHANGE IN WØRD 2 ØF THE ØFP-ID RECØRDS ØF DATA BLØCK
**** HAS BEEN DETECTED. PRØCESSING ØF THIS DATA BLØCK HAS BEEN TERMINATED.

2337 *** USER WARNING MESSAGE 2337, DATA BLØCK **** CAN NØT BE PRØCESSED DUE TØ A CØRE
INSUFFICIENCY ØF APPRØXIMATELY ********** DECIMAL WØRDS.

2338 *** USER WARNING MESSAGE 2338, DATA BLØCK **** MAY NØT BE FULLY CØMPLETED DUE TØ A CØRE
INSUFFICIENCY ØF APPRØXIMATELY ********** DECIMAL WØRDS.

2339 *** SYSTEM WARNING MESSAGE 2339, A CHANGE IN WØRD 2 ØF THE ØFP-ID RECØRDS ØF DATA BLØCK
**** HAS BEEN DETECTED. PRØCESSING ØF THIS DATA BLØCK HAS BEEN TERMINATED.

2340 *** USER WARNING MESSAGE 2340, MØDULE **** ****, HAS BEEN REQUESTED TØ DØ UNSYMMETRIC
DECØMPØSITIØN ØF A SYMMETRIC MATRIX.

2341 *** USER WARNING MESSAGE 2341, MØDULE **** **** HAS BEEN FURNISHED A SQUARE MATRIX MARKED
UNSYMMETRIC FØR SYMMETRIC DECØMPØSITIØN.

2342 *** USER WARNING MESSAGE 2342, UNRECØGNIZED APPRØACH PARAMETER ******** IN GPFDR INSTRUCTIØN.

The solution approach parameter can only be STATICS, REIGEN, DSO, DS1, FREQ, TRAN, BLKO, BLK1, CEIGEN, or PLA corresponding to the Rigid Format used.

2343 *** SYSTEM WARNING MESSAGE 2343, DATA BLØCK, *****, IS EITHER NØT -EQEXIN- ØR PØSSIBLY
INCØRRECT.

2344 *** SYSTEM WARNING MESSAGE 2344, GPFDR FINDS ELEMENT = **** ****, HAS AN ECT ENTRY LENGTH
TØØ LØNG FØR A PRØGRAM LØCAL ARRAY.

2345 *** SYSTEM WARNING MESSAGE 2345, GPFDR FINDS AND IS IGNØRING UNDEFINED ECT DATA WITH LØCATE
NUMBERS = ******** ******** ********.

2346 *** SYSTEM WARNING MESSAGE 2346, GPFDR FINDS DATA FØR EL-TYPE = **********, IN DATA BLØCK,
********** NØT TØ BE IN AGREEMENT WITH THAT WHICH IS EXPECTED.

2347 *** USER WARNING MESSAGE 2347, GPFDR FINDS TØØ MANY ACTIVE CØNNECTING GRID PØINTS FØR
ELEMENT ID = **********.

2348 *** SYSTEM WARNING MESSAGE 2348, GPFDR DØES NØT UNDERSTAND THE MATRIX-DICTIØNARY ENTRY FØR
ELEMENT ID = **********.

2379 *** SYSTEM FATAL MESSAGE 2379, LØGIC ****** ERRØR IN SDCMPS.

2380 *** USER WARNING MESSAGE 2380, MULTIPØINT CØNSTRAINT FØRCES NØT ØUTPUT IN ******, SEE QUEUED MESSAGES.

Other message(s) follow(s) indicating the reason(s) why a request for MPCFORCE in Case Control deck is being ignored.

2381 *** SYSTEM FATAL MESSAGE 2381, LØGIC ERRØR ****** IN SDCMPS.
CØNTENTS ØF /SDCØMX/ FØLLØW --

2382 *** USER WARNING MESSAGE 2382, ELEMENT MATRICES FØR ELEMENTS CØNGRUENT TØ ELEMENT ID = ***** ***** WILL BE RE-CØMPUTED AS THERE IS INSUFFICIENT CØRE AT THIS TIME TØ HØLD CØNGRUENCY MAPPING DATA.

2383 *** SYSTEM WARNING MESSAGE 2383, UNABLE TØ LØCATE CØNGRUENCY MAPPING DATA FØR ELEMENT ID = **********. ELEMENT MATRICES FØR THIS ELEMENT WILL, THEREFØRE, BE RE-CØMPUTED.

2384 *** USER WARNING MESSAGE 2384, CØNGRUENCY ØF ELEMENT ID = ********** WILL BE IGNØRED AND ITS ELEMENT MATRICES WILL BE RE-CØMPUTED AS THERE IS INSUFFICIENT CØRE AT THIS TIME TØ PERFØRM CØNGRUENCY MAPPING CØMPUTATIØNS.

2385 *** USER WARNING MESSAGE 2385, DESIRED NUMBER ØF EIGENVALUES EXCEED THE EXISTING NUMBER, ALL EIGENSØLUTIØNS WILL BE SØUGHT.

The desired number of eigenvalues specified on the EIGB card (NEP) or the EIGR card (ND) exceeds the rank of the $[K^{d}_{aa}]$ or $[M_{aa}]$ matrix.

2386 *** USER FATAL MESSAGE 2386, STIFFNESS MATRIX SINGULARITY CANNØT BE REMØVED BY SHIFTING.

Check the specification of masses on CØNM1, CØNM2, CMASSi, material definition and element property cards to ensure that the degrees-of-freedom in the analysis set are not all massless.

2387 *** USER WARNING MESSAGE 2387, PRØBLEM SIZE REDUCED TØ **** DUE TØ ØRTHØGØNALITY DRIFT ØR NULL TRIAL VECTØR.
ALL EXISTING MØDES MAY HAVE BEEN ØBTAINED. USE DIAG 16 TØ DETERMINE ERRØR BØUNDS.

The Tridiagonal Reduction method cannot generate a reduced problem size of the order prescribed in Section 10.6.2.3 of the Theoretical Manual. However, the desired number of accurate eigenvalues specified on the EIGB card (NEP) or the EIGR card (ND) may have been obtained. A detailed list of the computed error bounds could have been obtained by requesting DIAG 16 in the EXECUTIVE CØNTRØL DECK.

2388 *** USER WARNING MESSAGE 2388, USER SPECIFIED RANGE NØT USED FØR FEER BUCKLING, THE RØØTS ØF LØWEST MAGNITUDE ARE ØBTAINED.

The value of L1 specified on the EIGB card is ignored for buckling analysis by the Tridiagonal Reduction (FEER) method.

2389 *** USER WARNING MESSAGE 2389, PRØBLEM SIZE REDUCED. NØ MØRE TRIAL VECTØRS CAN BE ØBTAINED.

The desired number of eigenvalues specified on the EIGB card (NEP) or the EIGR card (ND) exceeds the number that can be calculated by the Tridiagonal Reduction (FEER) method

Check whether the requested number of eigenvalues exceeds the rank of the $[K^{d}_{aa}]$ or $[M_{aa}]$ matrix, which equals the number of existing eigenvalues.

2390 *** USER WARNING MESSAGE 2390, **** FEWER ACCURATE EIGENSØLUTIØNS THAN THE **** REQUESTED HAVE BEEN FØUND. USE DIAG 16 TØ DETERMINE ERRØR BØUNDS.

The number of eigenvalues passing the eigenvalue relative-error test is less than the number requested on the EIGB or EIGR card. The maximum allowable error is specified in field 5 on the above cards. A detailed list of the computed error bounds could have been obtained by requesting DIAG 16 in the EXECUTIVE CØNTRØL DECK. A checkpoint and restart should be employed to obtain additional accurate eigensolutions.

2391 *** SYSTEM FATAL MESSAGE 2381, PRØGRAM LØGIC ERRØR IN FEER.

An unexpected EØF or word count has been encountered. This is caused by a conflict between subroutine FCNTL and GINØ.

2392 *** USER INFØRMATIØN MESSAGE 2392, **** MØRE ACCURATE EIGENSØLUTIØNS THAN THE **** REQUESTED HAVE BEEN FØUND. USE DIAG 16 TØ DETERMINE ERRØR BØUNDS.

The number of eigenvalues passing the eigenvalue relative-error test is greater than the number requested on the EIGB or EIGR card. The maximum allowable error is specified in field 5 on the above cards. A detailed list of the computed error bounds could have been obtained by requesting DIAG 16 in the EXECUTIVE CØNTRØL DECK.

2393 *** USER WARNING MESSAGE 2393, THE REDUCED-SYSTEM EIGENVECTØR CØRRESPØNDING TØ EIGENVALUE **** DØES NØT MEET CØNVERGENCE CRITERIØN. ABSØLUTE RELATIVE ERRØR BETWEEN SUCCESSIVE ITERATES IS ****.

The accuracy of the corresponding physical eigenvector is in doubt. Refer to the Eigenvalue Summary Table for the largest error in the generalized mass matrix.

2396 *** USER WARNING MESSAGE 2396, DSCØMP CØMPUTED A ZERØ ØN THE DIAGØNAL. A VALUE ØF 1.0E-10 WILL BE USED. THE ACCURACY ØF THE DECØMPØSITIØN MAY BE IN DØUBT.

The matrix being decomposed is singular or a diagonal element is less than zero in the case of Cholesky decomposition.

2397 *** USER FATAL MESSAGE 2397, INVALID TØ HAVE AN Ø-SET WITH A NULL A-SET

There must be at least one degree of freedom in the A-SET even though EPØINTS may be present.

2399 *** USER WARNING MESSAGE 2399, ONLY THE FIRST ***** EIGENSØLUTIØNS CLØSEST TØ THE SHIFT PØINT (F1 ØR ZERØ) PASS THE FEER ACCURACY TEST FØR EIGENVECTØRS.

2401 *** USER WARNING MESSAGE 2401, ******** MATRIX IS NULL. AN ARBITRARY VALUE ØF 1.0 IS THEREFØRE ASSIGNED TØ THE RIGID BØDY ERRØR RATIØ (EPSILØN SUB E).

2402 *** USER FATAL MESSAGE 2402, NULL DIFFERENTIAL STIFFNESS MATRIX GENERATED IN SUBRØUTINE DS1A.

2404 *** USER FATAL MESSAGE 2404, GRID PØINTS 1 AND 3 ØF TRIM6 WITH ELEMENT ID = ******** HAVE SAME CØØRDINATES.

2405 *** USER FATAL MESSAGE 2405, GRID PØINTS 1, 3, AND 5 APPEAR TØ BE ØN A STRAIGHT LINE. ELEMENT TRIM6 WITH ID = ********.

2406 *** USER FATAL MESSAGE 2406, GRID PØINTS 1 AND 5 HAVE SAME CØØRDINATES. ELEMENT TRIM6 WITH ID = ********.

2407 *** USER FATAL MESSAGE 2407, MATRIX RELATING GENERALIZED PARAMETERS AND GRID PØINT DISPLACEMENTS IS SINGULAR. CHECK CØØRDINATES OF ELEMENT TRIM6 WITH ID = ********.

2408 *** USER FATAL MESSAGE 2408, GRID PØINTS 1 AND 3 OF TRPLT1 WITH ELEMENT ID = ******** HAVE SAME CØØRDINATES.

2409 *** USER FATAL MESSAGE 2409, GRID PØINTS 1, 3, and 5 APPEAR TØ BE ØN A STRAIGHT LINE. ELEMENT TRPLT1 WITH ID = ********.

2410 *** USER FATAL MESSAGE 2410, GRID PØINTS 1 AND 5 HAVE SAME CØØRDINATES. ELEMENT TRPLT1 WITH ID = ********.

2411 *** USER FATAL MESSAGE 2411, MATRIX RELATING GENERALIZED PARAMETERS AND GRID PØINT DISPLACEMENTS IS SINGULAR. CHECK CØØRDINATES ØF ELEMENT TRPLT1 WITH ID = ********.

2412 *** USER FATAL MESSAGE 2412, A SINGULAR MATERIAL MATRIX FØR ELEMENT ID = ******** HAS BEEN DETECTED BY SUBRØUTINE TLØDT1 WHILE TRYING TØ CØMPUTE THERMAL LØADS WITH TEMPP2 CARD DATA.

The thermal load vector generated by TEMPP2 data is not correctly applied to a TRPLT1 element.

2413 *** USER FATAL MESSAGE 2413, GRID PØINTS 1 AND 3 ØF TRSHL WITH ELEMENT ID = ******** HAVE SAME CØØRDINATES.

2414 *** USER FATAL MESSAGE 2414, GRID PØINTS 1, 3, AND 5 APPEAR TØ BE ØN A STRAIGHT LINE. ELEMENT TRSHL WITH ID = ********.

2415 *** USER FATAL MESSAGE 2415, GRID PØINTS 1 AND 5 HAVE SAME CØØRDINATES. ELEMENT TRSHL WITH ID = ********.

2416 *** USER FATAL MESSAGE 2416, MATRIX RELATING GENERALIZED PARAMETERS AND GRID PØINT DISPLACEMENTS IS SINGULAR. CHECK CØØRDINATES ØF ELEMENT TRSHL WITH ID = ********.

2417 *** USER FATAL MESSAGE 2417, A SINGULAR MATERIAL MATRIX FØR ELEMENT ID = ******** HAS BEEN DETECTED BY SUBRØUTINE TLØDSL WHILE TRYING TØ CØMPUTE THERMAL LØADS WITH TEMPP2 CARD DATA.

The thermal load vector generated by TEMPP2 data is not correctly applied to a TRSHL element.

2418 *** USER FATAL MESSAGE 2418, MATERIAL ID FØR MEMBRANE EFFECTS IS LESS THAN ØR EQUAL TØ ZERØ FØR TRSHL ELEMENT WITH ID = ********.

2419 *** SYSTEM FATAL MESSAGE 2419, PIVØT PØINT IS NØT EQUAL TØ TRSHL ELEMENT GRID PØINTS FØR ELEMENT ID = ********.

An error in the coordinate system tranformation has occurred. Temporary avoidance: remove coordinate system ID from field 7 of the GRID (or GRDSET) card.

2422 *** USER WARNING MESSAGE 2422, VISC DATA NØT PRØCESSED BY EMGPRØ.

CVISC data cards are used only in the direct method of dynamic problem formulations (Rigid Formats 7, 8, and 9). A warning is issued when these cards are encountered in the modal method of dynamic problem formulations (Rigid Formats 10, 11, and 12).

2423 *** USER FATAL MESSAGE 2423, DEPENDENT CØMPØNENT SPECIFIED MØRE THAN ØNCE ØN MPC CARDS AND/ØR IN RIGID ELEMENTS.
SIL VALUE = ********

The use of DIAG 21 in the Executive Control Deck will show the SIL (internal DØF) corresponding to the duplicated component.

2424 *** USER FATAL MESSAGE 2424, MACH BØX CØNTRØL PØINTS IMPRØPER. SINGULAR MATRIX RESULTED.

2425 *** USER FATAL MESSAGE 2425, MACH BØX GENERATIØN ØF BØXES FAILED.

2426 *** USER FATAL MESSAGE 2426, MACH NUMBER ********** WAS NØT FØUND ØN AEFACT CARD ********.

2427 *** USER FATAL MESSAGE 2427, SINGULAR MATRIX FØR INTERPØLATIØN IN ********.

2428 *** USER FATAL MESSAGE 2428, MACH NUMBER ********** WAS NØT FØUND IN PISTØN THEØRY ALPHA ARRAY.

2429 *** USER FATAL MESSAGE 2429, WRØNG NUMBER ØF WØRDS ØR CARD NØT FØUND FØR CARD ID ******** ASSØCIATED WITH CAERØ* ID ********.

2430 *** SYSTEM WARNING MESSAGE 2430, REQUESTED ******** PRECISIØN ******** BY ********. ******** IS LØGICAL CHØICE.

This message is issued when single or double precision is prescribed for a matrix utility module but could be better prescribed based on the data.

2431 *** SYSTEM WARNING MESSAGE 2431, REQUESTED TYPE ******** BY ********. TYPE ******** IS LØGICAL CHØICE.

This message is issued when real or complex output is prescribed for a matrix utility module but should be prescribed as indicated.

3001 *** SYSTEM FATAL MESSAGE 3001, ATTEMPT TØ ØPEN DATA SET *** IN SUBRØUTINE ****** WHICH WAS NØT DEFINED IN FIST.

Subroutine did not expect data block to be purged. Check data block requirements for module. This message is also a WARNING when STRESS output is requested in a heat transfer problem.

3002 *** SYSTEM FATAL MESSAGE 3002, EØF ENCØUNTERED WHILE READING DATA SET ********(FILE ***) IN SUBRØUTINE ******.

This message is issued when and End-Of-File occurs while trying to skip the header record. The data block is not in the proper format.

3003 *** SYSTEM FATAL MESSAGE 3003, ATTEMPT TØ READ PAST THE END ØF A LØGICAL RECØRD IN DATA SET ********(FILE ***) IN SUBRØUTINE ********.

This message is issued when the file is positioned at the beginning of a logical record and the record does not contain at least three words. Data block is not in proper format.

3004 *** SYSTEM FATAL MESSAGE 3004, INCØNSISTENT TYPE FLAGS ENCØUNTERED WHILE PACKING DATA SET ****.

3005 *** USER FATAL MESSAGE 3005, ATTEMPT TØ ØPERATE ØN SINGULAR MATRIX **** IN SUBRØUTINE ****.

A diagonal term does not exist for a column of (U). This is normally detected in DECØMP implying care was not taken in processing singular matrices in the calling routine.

3006 *** SYSTEM FATAL MESSAGE 3006, BUFFER ASSIGNED WHEN ØPENING DATA BLØCK **** FILE (****) CØNFLICTS WITH BUFFERS CURRENTLY ØPEN.

Computation of buffer pointers or allocation of open core is in error.

3007 *** SYSTEM FATAL MESSAGE 3007, ILLEGAL INPUT TØ SUBRØUTINE ****.

Subroutine **** has encountered data which it cannot process. This error should not be caused by user input data. A system or programming error is indicated. Go directly to the subroutine listing or description to determine the exact cause of the problem.

3008 *** SYSTEM FATAL MESSAGE 3008, INSUFFICIENT CØRE AVAILABLE FØR SUBRØUTINE ********.

This message implies that the particular subroutine does not have sufficient core to meet its demands. The subroutine or module description should be consulted to determine the core requirements.

3009 *** SYSTEM FATAL MESSAGE 3009, DATA TRANSMISSIØN ERRØR ØN DATA SET *******(FILE ***).

A conflict exists between the SGINØ subroutine for the UNIVAC 1108 and the resident NTRAN$. Either record SGINØ or remove the PLØT request from the NASTRAN job.

3010 *** SYSTEM FATAL MESSAGE 3010, ATTEMPT TØ MANIPULATE DATA SET ********(FILE ***) BEFØRE ØPENING FILE.

An operation other than ØPEN or CLØSE is requested on a file which is not defined in the FIST.

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY.

3159 *** USER INFØRMATIØN MESSAGE 3159, ALL SØLUTIØNS HAVE BEEN FØUND.

The FEER method has solved the entire problem. Any additional neighborhoods (as specified by the presence of EIGC bulk data continuation cards) are ignored.

3160 *** USER INFØRMATION MESSAGE 3160, MINIMUM ØPEN CØRE NØT USED BY FEER ********* WØRDS (********* K BYTES).

This message indicates the amount of open core, in both bytes and words, not used by FEER.

3161 *** USER WARNING MESSAGE 3161, DESIRED NUMBER OF EIGENSØLUTIONS ***** FØR NEIGHBØRHØØD *** ØF *** CENTERED AT ******** ******** EXCEEDS THE EXISTING NUMBER *****, ALL EIGENSØLUTIØNS WILL BE SØUGHT.

The desired number of eigenvalues specified on the EIGC bulk data continuation card exceeds the size of the eigenmatrix, which is the maximum possible number of existing eigenvalues.

3162 *** USER WARNING MESSAGE 3162, ATTEMPT TØ NØRMALIZE NULL VECTØR. NØ ACTIØN TAKEN.

The general vector normalization routine (CFNØR1 or CFNØR2) has a zero vector input to it.

3163 *** USER WARNING MESSAGE 3163, ALL **** SØLUTIONS HAVE FAILED ACCURACY TEST. NØ RØØTS FØUND.

The number of eigensolutions passing the relative error test is zero. The maximum allowable error for the relative error test is specified in field 7 of the EIGC bulk data card. A detailed list of the computed error bounds could have been obtained by requesting DIAG 12 in the Executive Control Deck.

3164 *** USER INFØRMATIØN MESSAGE 3164, ALL **** SØLUTIØNS ARE ACCEPTABLE.

All the eigensolutions obtained in the reduced problem corresponding to the point of interest pass the relative error test. The maximum allowable error for the relative error test is specified in field 7 of the EIGC bulk data card. A detailed list of the computed error estimates could have been obtained by requesting DIAG 12 in the Executive Control Deck.

3165 *** USER INFØRMATIØN MESSAGE 3165, **** SØLUTIØNS HAVE BEEN ACCEPTED AND **** SØLUTIØNS HAVE BEEN REJECTED.

In each neighborhood defined by a center, some eigensolutions passed the relative error test and some did not.

3166 *** USER INFØRMATIØN MESSAGE 3166, ***** MØRE ACCURATE EIGENSØLUTIØNS THAT THE ***** REQUESTED HAVE BEEN FØUND FØR NEIGHBØRHØØD *** ØF *** CENTERED AT ******** ********. USE DIAG 12 TØ DETERMINE ERRØR ESTIMATES.

The number of eigensolutions passing the relative error test is greater than the number requested on the corresponding EIGC bulk data continuation card. The maximum allowable error for the relative error test is specified in field 7 of the EIGC bulk data card. A detailed list of the computed error estimates could have been obtained by requesting DIAG 12 in the Executive Control Deck.

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY.

3169 *** USER WARNING MESSAGE 3169, PRIMARY ID ******** ØN A CNGRNT CARD ALSØ USED AS A SECØNDARY ID ØN THE SAME CARD. SECØNDARY ID IGNØRED.

3170 *** USER FATAL MESSAGE 3170, PRIMARY ID ******** ØN A CNGRNT CARD ALSØ USED AS A SECØNDARY ID ØN ANØTHER CNGRNT CARD.

3171 *** USER FATAL MESSAGE 3171, SECØNDARY ID ******** SPECIFIED AS CØNGRUENT TØ MØRE THAN ØNE PRIMARY ID.

3172 *** USER WARNING MESSAGE 3172, SECØNDARY ID ******** REDUNDANTLY SPECIFIED ØN CNGRNT CARDS. REDUNDANCIES IGNØRED.

3173 *** USER WARNING MESSAGE 3173, NØ NØN-ZERØ MATERIAL CØØRDINATE SYSTEM IDS ENCØUNTERED IN MØDULE CURV. {STRESSES / STRAINS/CURVATURES} IN MATERIAL CØØRDINATE SYSTEM NØT CØMPUTED.

Stresses or strains/curvatures are computed in module CURV only if non-zero material coordinate system ids are specified.

3174 *** SYSTEM FATAL MESSAGE 3174, SUBRØUTINE CURV* HAS RETURNED WITH ERRØR CØNDITIØN ***.
LØCATIØN CØDE = *** IN SUBRØUTINE CURV*
FILE NUMBER = ***

The information supplied by the message should enable a programmer to investigate the cause of the error.

3199 *** USER WARNING MESSAGE 3199, NØN-FATAL MESSAGES MAY HAVE BEEN LØST BY ATTEMPTING TØ QUEU MØRE THAN ***** MESSAGES.

3300 *** SYSTEM WARNING MESSAGE 3300, INVALID PARAMETER **** **** SUPPLIED TØ MØDULE DIAGØNAL, CØLUMN SUBSTITUTED.

3301 *** USER FATAL MESSAGE 3301, IHEX* ELEMENT NUMBER ******** INSUFFICIENT CØRE TØ CØMPUTE ELEMENT MATRIX.

3302 *** USER FATAL MESSAGE 3302, IHEX* ELEMENT NUMBER ******** ILLEGAL GEØMETRY, text.

The type of geometry error is identified in "text". The possibilities are:

AR EXCEEDED ALFA EXCEEDED BETA EXCEEDED	Either correct the element or increase the allowable value on the PIHEX card for this element.
REVERSED NUMBERING	The element was numbered in a clockwise fashion rather than counter-clockwise as required. This would result in a left-handed element coordinate system. Correct the numbering sequence on the CIHEXi card for this element.
CØØRDINATES ØF TWØ PØINTS ARE THE SAME	The coordinates of all connections of the element must be different.

3303 *** USER FATAL MESSAGE 3303, STRESSES REQUESTED FOR SET *** WHICH CONTAINS NØ VALID ELEMENT ID-S.

The set of elements for which stresses were requested in this subcase contains only ID's for nonexistent elements.

3304 *** USER FATAL MESSAGE 3304, PLØAD3 CARD FRØM LØAD SET ******** REFERENCES MISSING ØR NØN-ISØPARAMETRIC ELEMENT ********.

3305 *** USER FATAL MESSAGE 3305, PLØAD3 CARD FRØM LØAD SET ******** HAS INVALID GRID PØINT NUMBERS FØR ELEMENT ********.

Either the element does not connect the specified grid points, or the grid points do not identify the diagonal of a face of the element.

3306 *** USER FATAL MESSAGE 3306, SINGULAR JACØBIAN MATRIX FØR ISØPARAMETRIC ELEMENT NUMBER ********.

The element is severely warped or the outer surface of the element is folded through itself. Check the connection card for this element and the coordinates of the points it connects.

4000 *** USER WARNING MESSAGE 4000, ØNE SIDE ØF ELEMENT ******** CØNNECTING FØUR PØINTS IS NØT APPRØXIMATELY PLANAR.

Check CWEDGE and CHEXAi cards for order of grid point identification numbers, or incorrect grid point identification numbers.

4001 *** USER FATAL MESSAGE 4001, ELEMENT ******** DØES NØT HAVE CØRRECT GEØMETRY

6001 *** USER FATAL MESSAGE 6001, SUBSTRUCTURE DATA IS REQUIRED WITH THIS APPRØACH.

The program expects a SUBSTRUCTURE card following the CEND card if APP DISP, SUBS was used.

6002 *** USER WARNING MESSAGE 6002, INCØRRECT PHASE DATA.

The second word on the substructure command should be PHASEi, i = 1, 2, 3. The default is 2.

6003 *** USER FATAL MESSAGE 6003, ILLEGAL CØMMAND ØR ØPTIØN DEFINED ØN PREVIOUS CARD.

The program does not recognize the previous card. If any "subcommand" cards follow this error, they may produce this message until a legitimate command card is encountered.

6004 *** USER WARNING MESSAGE 6004, NØ PREFIX DEFINED AFTER EQUIVALENCE CØMMAND.

A prefix must be defined to identify the equivalent lower level basic substructures. To equivalence a basic substructure also requires the prefix be defined.

6005 *** USER FATAL MESSAGE 6005, ILLEGAL OR MISSING INPUT DATA GIVEN FØR PREVIØUS CØMMAND.

Either the basic command data is insufficient or mandatory additional subcommands are missing.

6006 *** USER FATAL MESSAGE 6006, DMAP ALTERS INTERFERE WITH SUBSTRUCTURE ALTERS.

The DMAP instruction numbers on the user ALTER data card overlaps or conflicts with the sections automatically modified. Use DIAG 23 to print the DMAP ALTER package or see Sections 5 and 3. Note also that the card APP DISPLACEMENT,SUBS,1 suppresses the automatic generation of DMAP instructions.

6007 *** SYSTEM FATAL MESSAGE 6007, IMPRØPER FILE SETUP FØR ****.

An external I/Ø operation has been defined but the file is missing or the card is improper. Occurs due to previously listed errors or from an illegal format in the MPTP or CASECC file.

6008 *** USER FATAL MESSAGE 6008, ILLEGAL INPUT ØN THE PREVIØUS CØMMAND. MISSING FILE NAME FØR I/Ø ØPERATIØN.

The EXIØ commands, SØFIN, SØFØUT, DUMP, etc. require a file name.

6009 *** SYSTEM FATAL MESSAGE 6009, UNRECØVERABLE ERRØR CØNDITIØNS IN SUBRØUTINE ASDMAP.

An unusual combination of previously listed errors or program errors will cause this condition.

6010 *** SYSTEM FATAL MESSAGE 6010, ILLEGAL VARIABLE TØ BE SET IN DMAP STATEMENT, (N).

The system has encountered an illegal type of word to be inserted in a DMAP sequence. For example, a floating point number is used instead of an integer on an input card.

6011 *** USER FATAL MESSAGE 6011, MISSING PASSWØRD ØR SØF DATA.

The SØF and PASSWØRD cards are mandatory. At least one SØF file, SØF(1), must be defined.

6012 *** SYSTEM FATAL MESSAGE 6012, FILE=**** IS PURGED ØR NULL AND IS REQUIRED IN PHASE1 SUBSTRUCTURE ANALYSIS.

The error will occur due to user DMAP alters or if no grid or scalar points are defined.

6013 *** USER FATAL MESSAGE 6013, ILLEGAL TYPE ØF PØINT DEFINED FØR SUBSTRUCTURE ANALYSIS. PØINT NUMBER=********.

An illegal type of grid point (i.e., aero or axisymmetric) has been encountered.

6014 *** USER FATAL MESSAGE 6014, INSUFFICIENT CØRE TØ LØAD TABLES IN MØDULE SUBPH1, CØRE=********.

At least three words of core per grid point are required.

6015 *** USER FATAL MESSAGE 6015, TØØ MANY CHARACTERS TØ BE INSERTED IN A DMAP LINE. N=***.

A BCD word has been defined with too many characters to fit the space in the DMAP. (Usual limit = 8.) Message could also occur if block data subprogram ASDBD has an error.

6016 *** USER FATAL MESSAGE 6016, TØØ MANY DIGITS TØ BE INSERTED IN DMAP VALUE=***.

An integer is limited to eight digits.

6022 *** USER FATAL MESSAGE 6022, SUBSTRUCTURE ***, GRID PØINT ***, CØMPØNENT ***, REFERENCED ØN *** CARD DØES NØT EXIST IN SØLUTIØN STRUCTURE ***.

6023 *** USER WARNING MESSAGE 6023, REQUESTED PLØT SET NØ. ********** HAS NØT BEEN DEFINED.

The requested set must be defined in the plot control deck from Case Control.

6101 *** SYSTEM FATAL MESSAGE 6101, REQUESTED SØF ITEM DØES NØT EXIST. ITEM ***, SUBSTRUCTURE ***.

Either the item has never been created or it only pseudo exists from a prior dry run.

6102 *** SYSTEM FATAL MESSAGE 6102, REQUESTED SUBSTRUCTURE DØES NØT EXIST. ITEM ***, SUBSTRUCTURE ***.

The user has probably misspelled the substructure name or is using the wrong SØF.

6103 *** SYSTEM FATAL MESSAGE 6103, REQUESTED SØF ITEM HAS INVALID NAME. ITEM ***, SUBSTRUCTURE ***.

Item name is illegal. Occurs with user DMAP ALTERS only.

6104 *** SYSTEM FATAL MESSAGE 6104, ATTEMPT TØ CREATE DUPLICATE SUBSTRUCTURE NAME ***.

6105 *** USER FATAL MESSAGE 6105, ATTEMPT TØ RE-USE SUBSTRUCTURE *** IN A REDUCE ØR CØMBINE ØPERATIØN. USE EQUIV SUBSTRUCTURE CØMMAND.

A single substructure may be reduced or combined more than once only after it is given a new name with the EQUIV substructure command.

6106 *** SYSTEM FATAL MESSAGE 6106, UNEXPECTED END ØF GRØUP ENCØUNTERED WHILE READING ITEM *** SUBSTRUCTURE ***.

Required data is missing or of inconsistent length.

6107 *** SYSTEM FATAL MESSAGE 6107, UNEXPECTED END ØF ITEM ENCØUNTERED WHILE READING ITEM *** SUBSTRUCTURE ***.

Required number of data groups are missing.

6108 *** SYSTEM FATAL MESSAGE 6108, INSUFFICIENT SPACE ØN SØF FØR ITEM ***, SUBSTRUCTURE ***.

6201 *** SYSTEM INFØRMATIØN MESSAGE 6201, *** FILES HAVE BEEN ALLØCATED TØ THE SØF WHERE
SIZE ØF FILE 1 = *** BLØCKS
:
SIZE ØF FILE *** = *** BLØCKS
AND WHERE A BLØCK CØNTAINS *** WØRDS

6202 *** USER FATAL MESSAGE 6202, THE REQUESTED NUMBER ØF FILES IS NØN-PØSITIVE.

SØF file declaration is missing or illegal.

6204 *** SYSTEM FATAL MESSAGE 6204, SUBRØUTINE *** - THE SUBRØUTINE SØFØPN SHØULD BE CALLED PRIØR TØ ANY ØF THE SØF UTILITY SUBRØUTINES.

6205 *** USER FATAL MESSAGE 6205, SUBRØUTINE *** - THE BUFFER SIZE HAS BEEN MØDIFIED.

The BUFSIZE entry on the NASTRAN card input has been changed.

6206 *** USER FATAL MESSAGE 6206, SUBRØUTINE *** - WRØNG PASSWØRD ØN SØF FILE ***.

6207 *** USER FATAL MESSAGE 6207, SUBRØUTINE *** - THE SØF FILE *** IS ØUT ØF SEQUENCE.

The SØF file declarations are in the worng order.

6208 *** USER FATAL MESSAGE 6208, SUBRØUTINE *** - THE SIZE ØF THE SØF FILE *** HAS BEEN MØDIFIED.

Only the last SØF file may be increased. None may be decreased.

6209 *** USER FATAL MESSAGE 6209, SUBRØUTINE *** - THE NEW SIZE ØF FILE *** IS TØØ SMALL.

6211 *** USER WARNING MESSAGE 6211, MØDULE *** - ITEM *** ØF SUBSTRUCTURE *** HAS ALREADY BEEN WRITTEN.

Program will not write over existing data.

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY.

6212 *** USER WARNING MESSAGE 6212, MØDULE *** - THE SUBSTRUCTURE *** DØES NØT EXIST.

6213 *** USER WARNING MESSAGE 6213, MØDULE *** - *** IS AN ILLEGAL ITEM NAME.

6215 *** USER WARNING MESSAGE 6215, MØDULE *** - ITEM *** ØF SUBSTRUCTURE *** PSEUDØ-EXISTS ØNLY.

6216 *** USER WARNING MESSAGE 6216, MØDULE *** - ITEM *** ØF SUBSTRUCTURE *** DØES NØT EXIST.

6217 *** USER WARNING MESSAGE 6217, MØDULE *** - *** IS AN ILLEGAL PARAMETER NAME.

6218 *** USER WARNING MESSAGE 6218, MØDULE *** - THE SUBSTRUCTURE *** CANNØT BE DESTRØYED BECAUSE IT IS AN IMAGE SUBSTRUCTURE.

6219 *** USER WARNING MESSAGE 6219, MØDULE *** RUN EQUALS DRY ØR STEP, AND, SUBSTRUCTURE *** ØR ØNE ØF THE NEW NAMES ALREADY EXISTS.

6220 *** USER WARNING MESSAGE 6220, MØDULE *** - RUN EQUALS GØ, AND, SUBSTRUCTURE *** ØR ØNE ØF THE NEW NAMES DØES NØT EXIST.

6222 *** SYSTEM FATAL MESSAGE 6222 - ATTEMPT TØ CALL SØFØPN MØRE THAN ØNCE WITHØUT CALLING SØFCLS.

6223 *** USER FATAL MESSAGE 6223 - SUBRØUTINE *** - THERE ARE NØ MØRE FREE BLØCKS AVAILABLE ØN THE SØF.

6224 *** SYSTEM FATAL MESSAGE 6224, SØF UTILITY SUBRØUTINE ***.

Text follows the message to describe the error.

6225 *** SYSTEM FATAL MESSAGE 6225, BLØCK NUMBER *** ØUT ØF RANGE ØF SØF FILES.

This means the SØF file does not contain all the data expected. Check previous jobs to verify where the intended SØF write operation may have failed, or determine if more information was expected.

6226 *** SYSTEM WARNING MESSAGE 6226, SUBRØUTINE SØFIØ - HIBLK PARAMETER FØR SØFIØ DID NØT CØNFØRM TØ PHYSICAL FILE. PARAMETER VALUE HAS BEEN CHANGED FRØM *** TØ ***.

This can be caused when the previous run using the SØF terminated abnormally. (CDC only.)

6227 *** SYSTEM FATAL MESSAGE 6227, AN ATTEMPT HAS BEEN MADE TØ ØPERATE ØN THE MATRIX ITEM *** ØF SUBSTRUCTURE *** USING SFETCH.

6228 *** USER INFØRMATIØN MESSAGE 6228, SUBSTRUCTURE *** IS ALREADY EQUIVALENT TØ SUBSTRUCTURE ***. ØNLY ITEMS NØT PREVIØUSLY EXISTING FØR *** HAVE BEEN MADE EQUIVALENT.

6229 *** USER INFØRMATIØN MESSAGE 6229, SUBSTRUCTURE *** HAS BEEN RENAMED TØ ***.

6230 *** USER WARNING MESSAGE 6230, SUBSTRUCTURE *** HAS NØT BEEN RENAMED BECAUSE *** ALREADY EXISTS ØN THE SØF.

6231 *** USER WARNING MESSAGE 6231, INSUFFICIENT CØRE AVAILABLE ØR ILLEGAL ITEM FØRMAT REQUIRES AN UNFØRMATTED DUMP TØ BE PERFØRMED FØR ITEM *** ØF SUBSTRUCTURE ***.

6232 *** SYSTEM FATAL MESSAGE 6232, ERRØR ØCCURRED WHILE INITIALIZING SØF FILE ***.

An error occurred while initializing an SØF file on the IBM 360/370. The nature of the error follows the message.

6233 *** USER WARNING MESSAGE 6233, THE ITEM STRUCTURE HAS BEEN CHANGED ØN THE SØF. NEW CAPABILITIES USING THESE ITEMS MAY NØT BE USED WITH THIS SØF.

6234 *** USER FATAL MESSAGE 6234, THE NASTRAN BUFFER SIZE IS TØØ SMALL FØR THE SØF FILE. MINIMUM BUFFER SIZE IS ***.

6235 *** USER WARNING MESSAGE 6235, THE ØLD SØF CØNTAINS NØ ITEM STRUCTURE INFØRMATIØN. THE LEVEL 16.0 ITEM STRUCTURE WILL BE USED.

6236 *** USER WARNING MESSAGE 6236, DURING THE CREATIØN ØF A NEW IMAGE SUBSTRUCTURE NAME, THE LAST CHARACTER ØF SUBSTRUCTURE NAME *** WAS TRUNCATED TØ MAKE RØØM FØR THE PREFIX.

6237 *** SYSTEM WARNING MESSAGE 6237, THE SØFTØC RØUTINE CAN HANDLE ØNLY *** ITEMS. ADDITIØNAL ITEMS WILL NØT BE SHØWN.

6301 *** SYSTEM FATAL MESSAGE 6301, DATA MISSING IN GØ MØDE FØR SUBSTRUCTURE ***, ITEM ***.

Item created in dry run mode has been deleted by the user or lost due to errors.

6302 *** SYSTEM FATAL MESSAGE 6302, *** IS ILLEGAL MATRIX TYPE FØR MØDULE CØMB2.

6303 *** SYSTEM FATAL MESSAGE 6303, HØRG TRANSFØRMATIØN MATRIX FØR SUBSTRUCTURE *** CANNØT BE FØUND ØN SØF.

6304 *** SYSTEM FATAL MESSAGE 6304, MØDULE CØMB2 INPUT MATRIX NUMBER *** FØR SUBSTRUCTURE *** HAS INCØMPATIBLE DIMENSIØNS.

Matrix dimensions conflict with those if its H or G transformation matrix.

6305 *** SYSTEM WARNING MESSAGE 6305, RECØRD NUMBER *** ØF CASESS IS NØT A RECØVER RECØRD. IT IS A *** RECØRD.

The step parameter for module RCØVR in incorrect. It should be the CASESS record number of a recover record.

6306 *** USER WARNING MESSAGE 6306, ATTEMPT TØ RECØVER DISPLACEMENTS FØR NØN-EXISTENT SUBSTRUCTURE ***.

6307 *** USER WARNING MESSAGE 6307, WHILE ATTEMPTING TØ RECØVER DISPLACEMENTS FØR SUBSTRUCTURE ***, THE DISPLACEMENTS FØR SUBSTRUCTURE *** WERE FØUND TØ EXIST IN DRY RUN FØRM ØNLY.

Before you can recover displacements of any substructure, you must first perform an actual solution. See RUN substructure command.

6308 *** USER WARNING MESSAGE 6308, NØ SØLUTIØN AVAILABLE FRØM WHICH DISPLACEMENTS FØR SUBSTRUCTURE *** CAN BE RECØVERED. HIGHEST LEVEL SUBSTRUCTURE FØUND WAS ***.

Solve the highest level substructure found or combine it to an even higher level and solve.

6309 *** SYSTEM FATAL MESSAGE 6309, INSUFFICIENT TIME REMAINING TØ RECØVER DISPLACEMENTS ØF SUBSTRUCTURE *** FRØM THØSE ØF SUBSTRUCTURE ***. (PRØCESSING USER RECØVER REQUEST FØR SUBSTRUCTURE ***.)

6310 *** SYSTEM WARNING MESSAGE 6310, INSUFFICIENT SPACE ØN SØF TØ RECØVER DISPLACEMENTS ØF SUBSTRUCTURE *** FRØM THØSE ØF SUBSTRUCTURE *** WHILE PRØCESSING USER RECØVER REQUEST FØR SUBSTRUCTURE ***.

Use the SØF substructure command and increase the size of the SØF and/or add more SØF units. Alternately, use EDIT to remove unwanted data.

6311 *** SYSTEM WARNING MESSAGE 6311, SDCØMP DECØMPØSITIØN FAILED ØN KØØ MATRIX FØR SUBSTRUCTURE ***.

The KØØ matrix has been changed from the original REDUCE run. The local effects of non-boundary loads will be ignored.

6312 *** USER INFØRMATIØN MESSAGE 6312, LEVEL *** DISPLACEMENTS FØR SUBSTRUCTURE *** HAVE BEEN RECØVERED AND SAVED ØN SØF.

6313 *** SYSTEM WARNING MESSAGE 6313, INSUFFICIENT CØRE FØR RCØVR MØDULE WHILE TRYING TØ PRØCESS PRINTØUT DATA BLØCKS FØR SUBSTRUCTURE.

6314 *** SYSTEM WARNING MESSAGE 6314, ØUTPUT REQUEST CANNØT BE HØNØRED. RCØVR MØDULE ØUTPUT DATA BLØCK *** IS PURGED.

An illegal type of output for the solution rigid format has been requested.

6315 *** USER WARNING MESSAGE 6315, RCØVR MØDULE IS UNABLE TØ FIND SUBSTRUCTURE *** AMØNG THØSE ØN EQSS. LØAD SET *** FØR THAT SUBSTRUCTURE WILL BE IGNØRED IN CREATING THE SØLN ITEM FØR FINAL SØLUTIØN STRUCTURE ***.

Illegal name used in PRINT or Save request.

6316 *** USER WARNING MESSAGE 6316, RCØVR MØDULE IS UNABLE TØ FIND LØAD SET *** FØR SUBSTRUCTURE *** AMØNG THØSE ØN LØDS. IT WILL BE IGNØRED IN CREATING THE SØLN ITEMS FØR FINAL SØLUTIØN STRUCTURE ***.

Case Control data was probably changed between SØLVE and first RECØVER steps. Message 6331 will define the error in SØLVE.

6317 *** SYSTEM WARNING MESSAGE 6317, RECØVER ØF DISPLACEMENTS FØR SUBSTRUCTURE *** ABØRTED.

6318 *** SYSTEM WARNING MESSAGE 6318, ØUTPUT REQUEST FØR REACTIØN FØRCES IGNØRED.

6319 *** SYSTEM WARNING MESSAGE 6319, DISPLACEMENT MATRIX FØR SUBSTRUCTURE *** MISSING. DISPLACEMENT ØUTPUT REQUESTS CANNØT BE HØNØRED AND SPCFØRCE ØUTPUT REQUESTS CANNØT BE HØNØRED UNLESS THE REACTIØNS HAVE BEEN PREVIØUSLY CØMPUTED.

6320 *** SYSTEM WARNING MESSAGE 6320, LØADC DATA MISSING FØR SUBSTRUCTURE ***, EXTERNAL STATIC LØAD SET ***.

No LØADC bulk data cards can be found on GEØM4 or GEØM4 is purged.

6321 *** USER INFØRMATIØN MESSAGE 6321, SUBSTRUCTURE PHASE3 RECØVER FØR FINAL SØLUTIØN STRUCTURE *** AND BASIC SUBSTRUCTURE ***.

6322 *** SYSTEM FATAL MESSAGE 6322, SØLN ITEM HAS INCØRRECT RIGID FØRMAT NUMBER. PHASE2 RIGID FØRMAT WAS *** AND PHASE3 IS ***.

The Rigid Format of Phase 3 must be the same as that used in Phase 2 to obtain the solution.

6323 *** USER WARNING MESSAGE 6323, NØ EIGENVALUES FØR THIS SØLUTIØN.

6324 *** USER FATAL MESSAGE 624, PHASE3 RECØVER ATTEMPTED FØR NØN-BASIC SUBSTRUCTURE ***.

Substructure Phase 3 can be executed only for basic substructures or their equivalents.

6325 *** USER WARNING MESSAGE 6325, SUBSTRUCTURE PHASE1, BASIC SUBSTRUCTURE *** ALREADY EXISTS ØN SØF. ITEMS WHICH ALREADY EXIST WILL NØT BE REGENERATED.

Use DESTRØY or EDIT to remove items which are to be regenerated.

6326 *** USER WARNING MESSAGE 6326, SUBSTRUCTURE ***, ITEM *** ALREADY EXISTS ØN SØF.

Follows message 6325, above.

6327 *** USER INFØRMATIØN MESSAGES 6327, SUBSTRUCTURE ***, SUBCASE *** IS IDENTIFIED BY *** SET *** IN LØDS ITEM. REFER TØ THIS NUMBER ØN LØADC CARDS.

6328 *** SYSTEM FATAL MESSAGE 6328, MØRE THAN 100 SUBCASES DEFINED. SGEN PRØGRAM LIMIT EXCEEDED.

To increase this limit to more than 100 subcases, change the dimensions of local arrays LØAD, MPC, and SPC in subroutine SGEN and change the IF test which causes termination.

6329 *** USER FATAL MESSAGE 6329, SUBSTRUCTURE ***, REFERENCES ØN *** CARD, IS NØT A CØMPØNENT BASIC SUBSTRUCTURE ØF SØLUTIØN STRUCTURE ***.

6330 *** USER FATAL MESSAGE 6330, SØLUTIØN SUBSTRUCTURE *** -- *** AND *** CARDS CANNØT BE USED TØGETHER. USE EITHER ØNE, BUT NØT BØTH.

6331 *** USER FATAL MESSAGE 6331, SØLUTIØN SUBSTRUCTURE *** -- LØADC SET *** REFERENCES UNDEFINED LØAD SET *** ØF BASIC SUBSTRUCTURE ***.

6332 *** SYSTEM FATAL MESSAGE 6332, CAN'T FIND LØAD VECTØR NUMBER *** IN LØAD MATRIX ØF *** CØLUMNS BY *** RØWS FØR SØLUTIØN STRUCTURE ***.

The wrong load matrix is being used.

6333 *** USER FATAL MESSAGE 6333, *** IS AN INVALID FØRMAT PARAMETER FØR MØDULE EXIØ.

An illegal value was given in the SØFIN, SØFØUT, DUMP, or RESTØRE command.

6334 *** USER WARNING MESSAGE 6334, EXIØ DEVICE PARAMETER SPECIFIES TAPE, BUT UNIT *** IS NØT A PHYSICAL TAPE.

6335 *** USER WARNING MESSAGE 6335, *** IS AN INVALID DEVICE FØR MØDULE EXIØ.

6336 *** USER INFØRMATIØN MESSAGE 6336, EXIØ FILE IDENTIFICATIØN. PASSWØRD ***. DATE ***. TIME ** ** **.

This message is caused when an I/Ø operation is requested. The date (in the form mm/dd/yy) and the time (in the form hh=mm=ss) indicate when the operation began.

6337 *** USER INFØRMATIØN MESSAGE 6337, *** BLØCKS (*** SUPERBLØCKS) ØF THE SØF SUCCESSFULLY DUMPED TØ EXTERNAL FILE ***.

6338 *** USER WARNING MESSAGE 6338, *** IS AN INVALID MØDE PARAMETER FØR MØDULE EXIØ.

6339 *** USER WARNING MESSAGE 6339, *** IS AN INVALID FILE PØSITIØNING PARAMETER FØR MØDULE EXIØ.

6340 *** USER WARNING MESSAGE 6340, SUBSTRUCTURE *** ITEM *** PSEUDØ-EXISTS ØNLY AND CANNØT BE CØPIED ØUT BY EXIØ.

6341 *** USER INFØRMATIØN MESSAGE 6341, SUBSTRUCTURE *** ITEM *** SUCCESSFULLY CØPIED FRØM *** TØ *** (***, ***).

The message follows message 6336 to indicate the substructure item that was copied, the input file, and the output file. The information in parentheses is the date and time in the same form as described under message 6336.

6342 *** USER WARNING MESSAGE 6342, SØF RESTØRE ØPERATIØN FAILED. THE RESIDENT SØF IS NØT EMPTY.

Use the NEW option on the SØF substructure command to create a "new" SØF.

6343 *** SYSTEM WARNING MESSAGE 6343, *** IS NØT AN EXTERNAL SØF FILE.

Either (1) tape contained no data, (2) first record read was not an ID or header record, (3) tape was incorrrectly positioned, or (4) GINØ buffer size was changed.

6344 *** USER INFØRMATIØN MESSAGE 6344, SØF RESTØRE ØF *** BLØCKS SUCCESSFULLY CØMPLETED..

6345 *** USER WARNING MESSAGE 6345, SUBSTRUCTURE *** ITEM *** IS DUPLICATED ØN EXTERNAL FILE ***. ØLDER VERSIØN (***, ***) IS IGNØRED.

6346 *** USER WARNING MESSAGE 6346, SUBSTRUCTURE *** ITEM *** NØT CØPIED. IT ALREADY EXISTS ØN THE SØF.

6347 *** USER INFØRMATIØN MESSAGE 6347, SUBSTRUCTURE *** ADDED TØ THE SØF.

HIGHER LEVEL SUBSTRUCTURE ********

CØMBINED SUBSTRUCTURE ********

LØWER LEVEL SUBSTRUCTURE ********

6348 *** USER WARNING MESSAGE 6348, SUBSTRUCTURE *** ITEM *** NØT FØUND ØN EXTERNAL FILE ***.

6349 *** USER INFØRMATIØN MESSAGE 6349, CØNTENTS ØF EXTERNAL SØF FILE *** FØLLØW.

6350 *** USER WARNING MESSAGE 6350, SØF APPEND ØF FILE *** FAILED. "text"

"text" explains why the append operation failed.

6351 *** USER WARNING MESSAGE 6351, DUPLICATE SUBSTRUCTURE NAME *** FØUND DURING SØF APPEND ØF FILE ***. THE SUBSTRUCTURE WITH THIS NAME ØN THE FILE BEING APPENDED WILL BE PREFIXED WITH "Q".

6352 *** USER INFØRMATIØN MESSAGE 6352, EXTERNAL SØF FILE *** SUCCESSFULLY APPENDED TØ THE RESIDENT SØF.

6353 *** USER INFØRMATIØN MESSAGE 6353, SUBSTRUCTURE *** ITEM *** HAS BEEN SUCCESSFULLY CØMPRESSED.

6354 *** USER INFØRMATIØN MESSAGE 6354, THERE ARE *** FREE BLØCKS (*** WØRDS) ØN THE RESIDENT SØF.

6355 *** SYSTEM INFØRMATIØN MESSAGE 6355, EXIØ TERMINATED WITH ERRØRS. DRY RUN MØDE ENTERED.

The parameter DRY has been set to -2 to prevent matrix operations from occurring downstream in this run.

6356 *** USER WARNING MESSAGE 6356, *** IS AN INVALID UNIT FØR MØDULE EXIØ, EXTERNAL FØRMAT.

6357 *** USER INFØRMATIØN MESSAGE 6357, SUBSTRUCTURE *** ITEM *** SUCCESSFULLY CØPIED FRØM *** TØ ***.

6358 *** SYSTEM WARNING MESSAGE 6358, ILLEGAL RIGID FØRMAT NUMBER *** IN SØLN ITEM FØR SUBSTRUCTURE ***. THE ITEM WILL NØT BE CØPIED.

6359 *** USER INFØRMATIØN MESSAGE 6359, SUBSTRUCTURE *** WAS ØRIGINALLY A SECØNDARY SUBSTRUCTURE. ØN THIS SØF, IT IS A PRIMARY SUBSTRUCTURE.

6360 *** SYSTEM WARNING MESSAGE 6360, SØFØUT (EXTERNAL) ENCØUNTERED AN UNSUPPØRTED TABLE ITEM ***. THE ITEM WILL NØT BE CØPIED.

6361 *** USER INFØRMATIØN MESSAGE 6361, PHASE1 SUCCESSFULLY EXECUTED FØR SUBSTRUCTURE ***.

6362 *** USER FATAL MESSAGE 6362, MPCS SET *** IS ILLEGAL. SUBSTRUCTURE *** GRID PØINT *** CØMPØNENT *** SIGNIFIES A NØN-UNIQUE DEPENDENT DEGREE ØF FREEDØM.

6363 *** USER WARNING MESSAGE 6363, INCØMPLETE DATA FØR SUBSTRUCTURE *** ITEM *** ØN ***. THE ALL ØUTPUT WILL BE PRØDUCED.

6365 *** USER WARNING MESSAGE 6365, REQUESTED ØUTPUT SET ID *** IS NØT DECLARED IN CASE CØNTRØL, ALL ØUTPUT WILL BE PRØDUCED.

Add 'SET N = list' to the Case Control deck.

6366 *** USER WARNING MESSAGE 6366, THE RECØVER ØUTPUT CØMMAND SØRT MUST APPEAR BEFØRE THE FIRST BASIC SUBCØMMAND. ANY ØTHER SØRT CØMMANDS ARE IGNØRED.

6367 *** USER WARNING MESSAGE 6367, ILLEGAL FØRMAT ØN THE RECØVER ØUTPUT CØMMAND ***, CØMMAND IGNØRED.

6368 *** USER WARNING MESSAGE 6368, THE SUBSTRUCTURE *** APPEARING ØN A BASIC CØMMAND IS NØT A CØMPØNENT ØF ***. ALL ØUTPUT REQUESTS UNTIL THE NEXT BASIC, PRINT, ØR SAVE ARE IGNØRED.

6369 *** USER FATAL MESSAGE 6369, SØLN ITEM HAS INCØRRECT RIGID FØRMAT NUMBER. SØLUTIØN RIGID FØRMAT WAS *** AND CURRENT NASTRAN EXECUTIØN RIGID FØRMAT IS ***.

6370 *** USER FATAL MESSAGE 6370, A SØLUTIØN ØN SUBSTRUCTURE *** WAS ATTEMPTED BUT PREVIØUS SØLUTIØN DATA EXISTED IN ITEM ***. THIS DATA MUST BE DELETED BEFØRE A NEW SØLUTIØN CAN BE PERFØRMED.

6371 *** USER WARNING MESSAGE 6371, MØDAL REDUCTIØN ENERGY CALCULATIØNS FØR SUBSTRUCTURE *** ABØRTED.

6501 *** USER FATAL MESSAGE 6501, THE MANUAL CØMBINE ØPTIØN HAS BEEN SPECIFIED, BUT NØ CØNNECTIØN SET WAS GIVEN.

6505 *** USER FATAL MESSAGE 6505, THE SYMMETRY ØPTIØN *** CØNTAINS AN INVALID SYMBØL.

See the CØMBINE substructure control description.

6506 *** USER FATAL MESSAGE 6506, THE CØMPØNENT SUBSTRUCTURE *** IS NØT ØNE ØF THØSE ØN THE CØMBINE CARD.

6507 *** USER FATAL MESSAGE 6507, THE SUBSTRUCTURE *** DØES NØT EXIST ØN THE SØF.

6508 *** USER FATAL MESSAGE 6508, THE NAME SPECIFIED FØR THE RESULTANT PSEUDØSTRUCTURE ALREADY EXISTS ØN THE SØF.

6510 *** USER FATAL MESSAGE 6510, THE REQUESTED CØMBINE ØPERATIØN REQUIRES SUBSTRUCTURE BULK DATA WHICH HAS NØT BEEN GIVEN.

A CØNNECT request requires CØNCT, CØNCT1, or RELES data.

6511 *** USER FATAL MESSAGE 6511, THE REQUESTED TRANS SET ID *** HAS NØT BEEN DEFINED BY BULK DATA.

6512 *** USER FATAL MESSAGE 6512, REDUNDANT CØNNECTIØN SET ID'S HAVE BEEN SPECIFIED.

6513 *** USER FATAL MESSAGE 6513, THE TRANS SET ID *** REQUESTED BY A GTRAN BULK DATA CARD HAS NØT BEEN DEIFNED.

6314 *** USER FATAL MESSAGE 6514, ERRØRS HAVE BEEN FØUND IN THE MANUALLY SPECIFIED CØNNECTIØN ENTRIES. SUMMARY FØLLØWS.

6515 *** USER FATAL MESSAGE 6515, GRID PØINT *** BASIC SUBSTRUCTURE *** DØES NØT EXIST.

6516 *** USER INFØRMATIØN MESSAGE 6516, ALL MANUAL CØNNECTIØNS SPECIFIED ARE ALLØWABLE WITH RESPECT TØ TØLER.

6517 *** USER FATAL MESSAGE 6517, THE BASIC SUBSTRUCTURE *** REFERRED TØ BY A RELES BULK DATA CARD CANNØT BE FØUND IN THE PRØBLEM TABLE ØF CØNTENTS.

6518 *** USER FATAL MESSAGE 6518, ØNE ØF THE CØMPØNENT SUBSTRUCTURES HAS BEEN USED IN A PREVIØUS CØMBINE ØR REDUCE.

Each substructure may be used in only one CØMBINE or REDUCE. The previous CØMBINE or REDUCE must be DESTRØYed before it may be used again. An alternative is to EQUIV the substructure in question to a new substructure and then use the new substructure in the desired CØMBINE operation. See message 6105.

6519 *** USER FATAL MESSAGE 6519, REDUNDANT NAMES FØR RESULTANT PSEUDØSTRUCTURE HAVE BEEN SPECIFIED.

6520 *** USER FATAL MESSAGE 6520, REDUNDANT VALUES FØR TØLER HAVE BEEN SPECIFIED.

6521 *** USER INFØRMATIØN MESSAGE 6521, MØDULE CØMB1 SUCCESSFULLY CØMPLETED.

6522 *** USER FATAL MESSAGE 6522, THE BASIC SUBSTRUCTURE *** REFERRED TØ BY A CØNCT1 BULK DATA CARD CANNØT BE FØUND IN THE PRØBLEM TABLE ØF CØNTENTS.

6523 *** USER FATAL MESSAGE 6523, THE BASIC SUBSTRUCTURE *** REFERRED TØ BY A CØNCT BULK DATA CARD CANNØT BE FØUND IN THE PRØBLEM TABLE ØF CØNTENTS.

6524 *** USER FATAL MESSAGE 6524, NØ. ØF CØLUMNS ØF MATRIX E IN MPY3 IN UNEQUAL TØ NØ. ØF CØLUMNS ØF MATRIX B FØR A(T)B + E PRØBLEM.

This is a system error if user is not using DMAP.

6525 (1) *** USER INFØRMATIØN MESSAGE 6525, TRIPLE MULTIPLY TIME ESTIMATE FØR MPY3 = ********** SECØNDS.

6525 (2) *** USER INFØRMATIØN MESSAGE 6525, TRIPLE MULTIPLY TIME ESTIMATE FØR MPYAD - (AT * B)* A + E = ********** SECØNDS.

6525 (3) *** USER INFØRMATIØN MESSAGE 6525, TRIPLE MULTIPLY TIME ESTIMATE FØR MPYAD - AT * (B*A) + E = ********** SECØNDS.

6526 *** USER INFØRMATIØN MESSAGE 6526, THE CENTER MATRIX IS TØØ LARGE FØR IN-CØRE PRØCESSING. ØUT-ØF-CØRE PRØCESSING WILL BE PERFØRMED.

Issued by the MPYS module.

6528 *** USER FATAL MESSAGE 6528, INCØMPATIBLE LØCAL CØØRDINATE SYSTEMS HAVE BEEN FØUND. CØNNECTIØN ØF PØINTS IS IMPØSSIBLE, SUMMARY FØLLØWS.

6530 *** USER FATAL MESSAGE 6530, THE BASIC SUBSTRUCTURE *** REFERRED TØ BY A GTRAN CARD CANNØT BE FØUND IN THE PRØBLEM TABLE ØF CØNTENTS.

6531 *** USER FATAL MESSAGE 6531, NØ CØNNECTIØNS HAVE BEEN FØUND DURING THE AUTØMATIC CØNNECTIØN PRØCEDURE.

6533 *** USER FATAL MESSAGE 6533, ØPTIØNS PA HAS BEEN SPECIFIED BUT THE LØAP ITEM ALREADY EXISTS FØR SUBSTRUCTURE ***.

User must delete old appended loads before running with new appended loads.

6534 *** USER FATAL MESSAGE 6534, ØPTIØNS PA HAS BEEN SPECIFIED BUT THE STRUCTURE *** DØES NØT EXIST.

6535 *** USER FATAL MESSAGE 6535, MØDULE CØMB1 TERMINATING DUE TØ ABØVE SUBSTRUCTURE CØNTRØL ERRØRS.

6536 *** USER FATAL MESSAGE 6536, MØDULE CØMB1 TERMINATING DUE TØ ABØVE ERRØRS IN BULK DATA.

6537 *** USER FATAL MESSAGE 6537, MØDULE CØMB1 TERMINATING DUE TØ ABØVE ERRØRS.

6551 *** USER FATAL MESSAGE 6551, MATRIX B IN MPY3 IS NØT SQUARE FØR A(T)BA + E PRØBLEM.

6552 *** USER FATAL MESSAGE 6552, NØ. ØF RØWS ØF MATRIX A IN MPY3 IS UNEQUAL TØ NØ. ØF RØWS ØF MATRIX B FØR A(T)B + E PRØBLEM.

6553 *** USER FATAL MESSAGE 6553, NØ. ØF RØWS ØF MATRIX A IN MPY3 IS UNEQUAL TØ NØ. ØF CØLUMNS ØF MATRIX B FØR A(T)BA + E PRØBLEM.

6554 *** USER FATAL MESSAGE 6554, NØ. ØF CØLUMNS ØF MATRIX E IN MPY3 IS UNEQUAL TØ NØ. ØF CØLUMNS ØF MATRIX A FØR A(T)BA + E PRØBLEM.

6555 *** USER FATAL MESSAGE 6555, MATRIX E IN MPY3 IS NØT SQUARE FØR A(T)BA + E PRØBLEM.

6556 *** USER FATAL MESSAGE 6556, NØ. ØF RØWS ØF MATRIX E IN MPY3 IS UNEQUAL TØ NØ. ØF RØWS ØF MATRIX B FØR BA + E PRØBLEM.

6557 *** USER FATAL MESSAGE 6557, UNEXPECTED NULL CØLUMN ØF A(T) ENCØUNTERED.

Issued by MPY3 module.

6558 *** USER FATAL MESSAGE 6558, INSUFFICIENT TIME REMAINING FØR MPY3 EXECUTIØN.

6659 *** USER FATAL MESSAGE 6659, NØ. ØF RØWS ØF MATRIX E IN MPY3 IS UNEQUAL TØ NØ. ØF CØLUMNS ØF MATRIX A FØR A(T)B + E PRØBLEM.

6601 *** USER FATAL MESSAGE 6601, REQUEST TØ REDUCE PSEUDØSTRUCTURE *** INVALID. DØES NØT EXIST ØN THE SØF.

6602 *** USER FATAL MESSAGE 6602, THE NAME *** CANNØT BE USED FØR THE REDUCED PSEUDØSTRUCTURE. IT ALREADY EXISTS ØN THE SØF.

6603 *** USER FATAL MESSAGE 6603, A BØUNDARY SET MUST BE SPECIFIED FØR A REDUCE ØPERATIØN.

6604 *** USER WARNING MESSAGE 6604, A BØUNDARY SET HAS BEEN SPECIFIED FØR ***, BUT IT IS NØT A CØMPØNENT ØF THE PSEUDØSTRUCTURE BEING REDUCED. THE BØUNDARY SET WILL BE IGNØRED.

6605 *** USER WARNING MESSAGE 6605, A BØUNDARY SET HAS BEEN SPECIFIED FØR *** BUT IT IS NØT A PHASE1 BASIC SUBSTRUCTURE. THE BØUNDARY SET WILL BE IGNØRED.

6606 *** USER FATAL MESSAGE 6606, BØUNDARY SET *** SPECIFIED IN CASE CØNTRØL HAS NØT BEEN DEFINED BY BULK DATA.

No BDYC bulk data has been entered.

6607 *** USER FATAL MESSAGE 6607, NØ BDYS ØR BDYS1 BULK DATA HAS BEEN INPUT TØ DEFINE BØUNDARY SET ***.

6608 *** USER FATAL MESSAGE 6608, THE REQUEST FØR BØUNDARY SET ***, SUBSTRUCTURE *** WAS NØT DEFINED.

6609 *** USER INFORMATION MESSAGE 6609, NØ BØUNDARY SET HAS BEEN SPECIFIED FØR CØMPØNENT *** ØF PSEUDØSTRUCTURE ***. ALL DEGREES ØF FREEDØM WILL BE REDUCED.

6610 *** USER WARNING MESSAGE 6610, DEGREES ØF FREEDØM AT GRID PØINT *** CØMPØNENT SUBSTRUCTURE *** INCLUDED IN A BØUNDARY SET DØ NØT EXIST. REQUEST WILL BE IGNØRED.

6611 *** USER FATAL MESSAGE 6611, GRID PØINT *** SPECIFIED IN BØUNDARY SET *** FØR SUBSTRUCTURE *** DØES NØT EXIST.

6612 *** USER FATAL MESSAGE 6612, THE REDUCE ØPERATIØN REQUIRES SUBSTRUCTURE BULK DATA WHICH HAS NØT BEEN GIVEN.

6613 *** USER FATAL MESSAGE 6613, FØR RUN=GØ, THE REDUCED SUBSTRUCTURE *** MUST ALREADY EXIST.

6614 *** USER FATAL MESSAGE 6614, ILLEGAL ØR NØN-EXISTANT STRUCTURE NAME USED ABØVE.

6615 *** USER FATAL MESSAGE 6615, ILLEGAL BØUNDARY SET IDENTIFICATIØN NUMBER.

6616 *** USER INFØRMATIØN MESSAGE 6616, MØDULE REDUCE SUCCESSFULLY CØMPLETED.

6617 *** USER FATAL MESSAGE 6617, ØLDMØDES SET AND REQUESTED SØF ITEM DØES NØT EXIST. ITEM ***, SUBSTRUCTURE.

6618 *** USER FATAL MESSAGE 6618, ØLDMØDES NØT SET AND REQUESTED SØF ITEM MUST BE DELETED. ITEM ***, SUBSTRUCTURE ***.

6619 *** USER FATAL MESSAGE 6619, ØLDBØUND SET AND REQUESTED SØF ITEM DØES NØT EXIST. ITEM ***, SUBSTRUCTURE ***.

6620 *** USER FATAL MESSAGE 6620, ØLDBØUND NØT SET AND REQUESTED SØF ITEM MUST BE DELETED, ITEM ***, SUBSTRUCTURE ***.

6621 *** USER FATAL MESSAGE 6621, FIXED SET *** SPECIFIED IN CASE CØNTRØL HAS NØT BEEN DEFINED BY BULK DATA.

6622 *** USER WARNING MESSAGE 6622, A FIXED SET HAS BEEN SPECIFIED FØR ***, BUT IT IS NØT A CØMPØNENT ØF THE PSEUDØSTRUCTURE BEING PRØCESSED. THE FIXED SET WILL BE IGNØRED.

6623 *** USER FATAL MESSAGE 6623, SUBSTRUCTURE *** HAS DUPLICATE NAMES IN BDYC DATA SET ***.

6624 *** USER FATAL MESSAGE 6624, GRID PØINT *** SPECIFIED IN FIXED SET *** FØR SUBSTRUCTURE *** DØES NØT EXIST.

6625 *** USER WARNING MESSAGE 6625, DEGREES ØF FREEDØM AT GRID PØINT *** CØMPØNENT SUBSTRUCTURE *** INCLUDED IN A FIXED SET DØ NØT EXIST. REQUEST WILL BE IGNØRED.

6626 *** USER FATAL MESSAGE 6626, NØ BDYS ØR BDYS1 BULK DATA HAS BEEN INPUT TØ DEFINE FIXED SET ***.

6627 *** USER FATAL MESSAGE 6627, NØ EIG* DATA CARDS SPECIFIED FØR SET ID ***, SUBSTRUCTURE ***.

6628 *** USER FATAL MESSAGE 6628, NØ EIGC ØR EIGR DATA CARDS SPECIFIED FØR SET ID ***, SUBSTRUCTURE ***.

6629 *** USER FATAL MESSAGE 6629, NØ EIGC DATA CARD SPECIFIED WITH EIGP DATA CARD SET ID ***, SUBSTRUCTURE ***.

6630 *** USER INFØRMATIØN MESSAGE 6630, FØR DRY ØPTIØN IN MØDAL REDUCE, INPUT DATA WILL BE CHECKED BUT NØ SØF TABLE ITEMS WILL BE CREATED.

6631 *** USER PØTENTIALLY FATAL MESSAGE 6631, IN CØMPLEX MØDAL REDUCE, ØNLY ØNE H TRANSFØRMATIØN MATRIX IS PRESENT ØN SØF FØR NØNSYMMETRIC REDUCTIØN.

6632 *** USER FATAL MESSAGE 6632, MØDULE ***, NASTRAN MATRIX FILE FØR I/Ø ØF SØF ITEM ***, SUBSTRUCTURE ***, IS PURGED.

6633 *** USER FATAL MESSAGE 6633, FØR SUBSTRUCTURE *** TØTAL NUMBER ØF MØDAL CØØRDINATES (***) IS LARGER THAN THE NUMBER ØF INTERIØR DØF (***).

6634 *** USER FATAL MESSAGE 6634, IN MØDULE MREDUCE WITH USER MØDE=2, THE CØNSTRAINT FØRCES MATRIX IS INCØMPATIBLE WITH THE NUMBER ØF MØDES (***).

6635 *** USER WARNING MESSAGE 6635, CDCØMP DECØMPØSITIØN FAILED ØN KII MATRIX FØR SUBSTRUCTURE ***.

6636 *** USER INFØRMATIØN MESSAGE 6636, NMAX AND RANGE SUBCØMMANDS ARE IGNØRED UNDER USERMØDE= TYPE 2.

6637 *** USER FATAL MESSAGE 6637, ØLDBØUND HAS BEEN SPECIFIED BUT THE BØUNDARY PØINTS FØR SUBSTRUCTURE *** HAVE BEEN CHANGED.

The boundary set data for the current problem is different from the boundary set data which created the UPRT SØF item for this substructure.

6638 *** USER FATAL MESSAGE 6638, IN MØDULE MREDUCE WITH USERMØDE=2, THE CØNSTRAINT FØRCES MATRIX (QSM) CANNØT BE PURGED.

6900 *** USER INFØRMATIØN MESSAGE 6900, LØADS HAVE BEEN SUCCESSFULLY APPENDED FØR SUBSTRUCTURE ***.

6901 *** USER INFØRMATIØN MESSAGE 6901, ADDITIØNAL LØADS HAVE BEEN SUCCESSFULLY MERGED FØR SUBSTRUCTURE.

6951 *** USER FATAL MESSAGE 6951, INSUFFICIENT CØRE TØ LØAD TABLES. IN MØDULE LØDAPP, CØRE = ***.

The total number of load sets times two must fit in core.

6952 *** USER FATAL MESSAGE 6952, REQUESTED SUBSTRUCTURE *** DØES NØT EXIST.

6953 *** SYSTEM FATAL MESSAGE 6953, A WRØNG CØMBINATIØN ØF LØAD VECTØRS EXISTS FØR SUBSTRUCTURE ***.

All load set ID's must be unique for each basic substructure.

6954 *** SYSTEM FATAL MESSAGE 6954, THE **** ITEM EXISTS BUT HAS NØ ASSØCIATED PVEC ITEM FØR SUBSTRUCTURE ********.

A load set table exists but the load vectors have been removed.

6956 *** USER FATAL MESSAGE 6956, INSUFFICIENT TIME REMAINING FØR MØDULE LØDAPP, TIME LEFT = TIME LEFT = ********.

7019 *** USER INFØRMATIØN MESSAGE 7019. MØDULE DSCHK IS EXITING FØR REASØN *** ØN ITERATIØN NUMBER ****** / PARAMETER VALUES ARE AS FØLLØWS DØNE = **********, SHIFT = **********, DSEPSI = **********.

See Section 3.5 for a discussion of Rigid Format 4 output features.

7. NASTRAN DICTIONARY

7.1 NASTRAN DICTIONARY

This section contains descriptions of mnemonics, acronyms, phrases, and other commonly used NASTRAN terms. The first column of the Dictionary contains the NASTRAN terms in alphabetical order. The second column contains a code indicating a general category for each term. The codes and categories, along with general references to the Programmer's Manual and User's Manual, are as follows:

Code	Category	General Reference
DBM	Data Block - Matrix	PM-2
DBML	Data Block - Matrix List	PM-2
DBS	Data Block - Substructure Item	UM-1.10
DBT	Data Block - Table	PM-2
EM	Executive Module	UM-5.7
FMA	Functional Module - Aero	PM-4
FMH	Functional Module - Heat	PM-4
FMM	Functional Module - Matrix Operation	UM-5.4
FMS	Functional Module - Structural	PM-4
FMSS	Functional Module - Substructuring	UM-5.9
FMU	Functional Module - Utility	UM-5.5
FMX	Functional Module - User	UM-5.6
IA	Input - Executive Control	UM-2.2
IB	Input - Bulk Data	UM-2.4
IC	Input - Case Control	UM-2.3
IS	Input - Substructure Control	UM-2.7
L	Rigid Format Label	UM-3
M	Miscellaneous	
NP	NASTRAN card parameter	UM-2.1
P	Parameter Name	UM-3
PH	Common Phrase or Term	
PU	Parameter set by user	UM-2.4

The third column of the Dictionary contains a definition or description of the terms given in the first column. References to the User's Manual are indicated by UM-i and the Programmer's Manual by PM-i, where i is the section number of the manual. References to particular rigid formats are indicated by D-i, H-i, or A-i where i is the rigid format number in the displacement, heat, and aero approaches, respectively.

A	P	Parameter value used to control utility module MATGPR print of A-set matrices.
ABFL	DBM	$[A_{b,f\ell}]$ - Hydroelastic boundary area factor matrix.
ABFLT	DBM	Transpose of $[A_{b,f\ell}]$.
ACCE	IC	Abbreviated form of ACCELERATIØN.
ACCE	IS	Acceleration output requests.
ACCELERATIØN	IC	Output request for acceleration vector. (UM-2.3, 4.2)
ACPT	DBT	Aerodynamic Connection and Property Data.
Active column	PH	Column containing at least one nonzero term outside the band.
ADD	FMM	Functional module to add two matrices together.
ADD	M	Parameter constant used in utility module PARAM.
ADD5	FMM	Functional module to add up to five matrices together.
ADR	FMS	Aerodynamic data recovery.
ADUMi	IB	Defines attributes of dummy elements 1 through 9.
AEFACT	IB	Used to input lists of real numbers for aeroelastic analysis.
AERØ	DBT	Aerodynamic Matrix Generation Data.
AERØ	IB	Gives basic aerodynamic parameters.
AERØF	IC	Aerodynamic force output request.
AERØFØRCE	IC	Requests frequency dependent aerodynamic loads on interconnection points in aeroelastic response analysis.
AJJL	DBML	Aerodynamic Influence Matrix List.
ALL	IC	Output request for all of a specified type of output.
ALLEDGE TICS	IC	Request tic marks on all edges of X-Y plot.
ALTER	IA	Alter statement for DMAP or rigid format.
ALWAYS	P	Parameter set to -1 by a PARAM statement.
AMG	FMA	Aerodynamic Matrix Generator.
AMP	FMA	Aerodynamic Matrix Processor.
AND	M	Parameter constant used in executive module PARAM.
AØUT$	M	Indicates restart with solution set output request.
APD	FMA	Aerodynamic pool distributor and element generator.
APP	IA	Control card which specifies approach (DISP, DMAP, HEAT or AERØ)
APP	P	Approach flag used for modules with several functions.

APPEND	M	File may be extended (see FILE).
ASDMAP	FMSS	Assemble substructure DMAP.
ASET	IB	Analysis set coordinate definition card.
ASET1	IB	Analysis set coordinate definition card.
AUTØ	IC	Requests X-Y plot of autocorrelation function.
AUTØ	DBT	Autocorrelation function table.
AXES	IC	Defines orientation of object for structure plot.
AXIC	DBT	Generated by Input File Processor 3 (IFP3) for axisymmetric conical shell problems.
AXIC	IB	Axisymmetrical conical shell definition card. When this card is present, most other bulk data cards may not be used.
AXIF	IB	Controls the formulation of a hydroelastic problem.
AXISYM$	M	Indicates restart with conical shell or hydroelastic elements.
AXISYMMETRIC	IC	Selects boundary conditions for axisymmetric shell problems or specifies the existence of hydroelastic fluid harmonics.
AXSLØT	IB	Controls the formulation of acoustic analysis problems.

B	PH	Upper semiband of matrix.
B2DD	DBM	$[B^2_{dd}]$ - Partition of direct input damping matrix.
B2PP	DBM	$[B^2_{pp}]$ - Direct input damping matrix for all physical points.
B2PP	IC	Selects direct input structural damping or thermal capacitance matrices.
B2PP$	M	Indicates restart with change in direct input damping matrices.
BAA	DBM	$[B_{aa}]$ - Partition of damping matrix.
BALL EDGE TICS	IC	Request for all edge tic marks to be plotted on lower frame of an X-Y plot.
BAR	IC	Requests structure plot for all bar elements.
BARØR	IB	Bar orientation default definition.
BASIC	IS	Basic substructure for output requests.
BBAR	PH	Lower semiband of matrix.
BDD	DBM	$[B_{dd}]$ - Damping matrix used in direct formulation of dynamics problems (D-7 thru D-9, A-11).
BDEBA	P	Parameter used to indicate equivalence of BDD and BAA.
BDPØØL	DBT	Hydroelastic boundary description table.
BDYC	IB	Combination of substructure boundary sets of retained degrees of freedom or fixed degrees of freedom for modes calculation.
BDYLIST	IB	Structure-fluid hydroelastic boundary definition.
BDYS	IB	Boundary set definition for substructuring.
BDYS1	IB	Alternate boundary set definition for substructuring.
BEGIN	EM	The first DMAP statement is always BEGIN.
BEGIN BULK	IB	Control card which marks the end of the case control deck. Cards following this card are assumed to be bulk data cards.
BETAD	PU	Factor in integration algorithm in transient heat transfer analysis.
BFF	DBM	$[B_{ff}]$ - Partition of damping matrix
BGG	DBM	$[B_{gg}]$ - Damping matrix generated by Structural Matrix Assembler.
BGPA	DBT	Basic Grid Point Definition Table - aerodynamics.
BGPDT	DBT	Basic Grid Point Definition Table.
BGSS	DBS	Basic grid point coordinates.
BHH	DBM	$[B_{hh}]$ - Partition of damping matrix.
BKLO	P	Constant parameter value used in functional module SDR2 in the Buckling Analysis (D-5) and Normal Modes with Differential Stiffness (D-13) Rigid Formats.

BKL1	P	Constant parameter value used in functional module SDR2 in the Buckling Analysis Rigid Format (D-5).
BLANK FRAMES	IC	Requests blank frames between structure plots (UM-4.1).
BLEFT TICS	IC	Request for left edge tic marks to be plotted on bottom frame of an X-Y plot.
BMG	GMS	Generates DMIG card images describing interconnection of fluid and structure.
BMTX	DBS	Viscous damping matrix.
BNN	DBM	$[B_{nn}]$ - Partition of damping matrix.
BØTH	IC	Bulk data echo option - Requests both unsorted and sorted printout of bulk data deck.
BØUNDARY	IS	Defines set of retained degrees of freedom.
BØV	P	Aerodynamic parameter equal to the reference semichord divided by velocity.
BPI	IC	Bits per inch - Plot tape density must be specified on control cards in addition to this data card. The required value will vary from one installation to another.
BQG	DBM	Single-point forces of constraint for a Buckling Analysis problem (D-5).
BRECØVER	IS	Basic Substructure Data Recovery.
BRIGHT TICS	IC	Request for right edge tick marks to be plotted on bottom frame for X-Y plot.
BSHH	DBM	Total modal damping matrix - h set.
BUCKLING	IA	Selects rigid format for buckling analysis.
BUCKLING	P	Constant parameter value used in functional module READ in the Buckling Analysis Rigid Format (D-5).
BUCKLING	P	Used in printing rigid format error messages for Buckling Analysis (D-5).
BUFFSIZE	NP	Defines the number of words in a GINØ buffer.
Bulk Data Deck	PH	One of the data decks necessary to run a problem under the NASTRAN system. This deck begins after the BEGIN BULK card and ends with the ENDDATA card, and contains the data of the mathematical model. The format of each bulk data card is fixed field, 8 or 16 columns for each value.

C	M	Used in parameter section of DMAP statement. Indicates that parameter is a constant.
C	PH	Symbol for active column in triangular decomposition ($\bar{C}$ used for active rows).
CAERØ1	IB	Aerodynamic panel element, doublet lattice theory.
CAERØ2	IB	Aerodynamic body element, doublet lattice theory.
CAERØ3	IB	Aerodynamic surface element, Mach box.
CAERØ4	IB	Aerodynamic macro element, strip theory.
CAERØ5	IB	Aerodynamic macro element, piston theory.
CALCØMP	IC	Request California Computer plotter.
CAMERA	IC	Selects one or both of the two cameras for the SC 4020 cathode ray tube electronic plotter. This information must usually also be given to the plotter operator on the run submittal slip which will vary from one installation to another. (UM-4)
CARDNØ	P	Parameter used to accumulate a count of all card output punched except the NASTRAN restart dictionary.
CASE	FMS	Extracts user request from CASECC for current loop in dynamics rigid formats (D-7 thru D-12).
Case Control Deck	PH	One of the data decks necessary to run a problem under the NASTRAN system. It contains cards which select particular data sets from the Bulk Data Deck, output request cards and titling information. Cards in this deck are free field.
CASECC	DBT	Case control data block.
CASEXX	DBT	Case control data block as modified by functional module CASE.
CASEYY	DBT	Appended case control data table.
CASEZZ	DBT	CASEYY reduced to ØFREQ list.
CAXIF2	IB	Acoustic core element connection definition card.
CAXIF3	IB	Acoustic triangular element connection definition card.
CAXIF4	IB	Acoustic quadrilateral element connection definition card.
CBAR	IB	Bar element connection definition card.
CCØNEAX	IB	Axisymmetrical conical shell element connection card.
CDAMP1	IB	Scalar damper connection definition card.
CDAMP2	IB	Scalar damper property and connection definition card.
CDAMP3	IB	Scalar damper connection definition card (connecting scalar points).
CDAMP4	IB	Scalar damper property and connection definition card (connecting scalar points).

CDUMi	IB	Defines definition card for dummy elements 1 through 9.
CEAD	FMS	Complex Eigenvalue Analysis - Displacement.
CEIF	P	Parameter used in SDR2 in Complex Eigenvalue Analysis (D-7 and D-10).
CEIGN	P	Parameter used in VDR in Complex Eigenvalue Analysis (D-7 and D-10).
CELAS1	IB	Scalar spring connection definition card.
CELAS2	IB	Scalar spring property and connection definition card.
CELAS3	IB	Scalar spring connection definition card (connecting scalar points).
CELAS4	IB	Scalar spring property and connecting definition card (connecting scalar points).
CEND	IA	The last card of the Executive Control Deck.
CFLUID2	IB	Fluid core element connection definition card.
CFLUID3	IB	Fluid triangular element connection definition card.
CFLUID4	IB	Fluid quadrilateral element connection definition card.
CHBDY	IB	Boundary element connection definition card for heat transfer analysis.
CHECK	IS	Checks contents of external file.
Checkpoint	PH	The process of writing selected data blocks onto the New Problem Tape for subsequent restarts.
CHEXA1	IB	Hexahedron element connection definition card - five tetrahedra.
CHEXA2	IB	Hexahedron element connection definition card - ten tetrahedra.
CHKPNT	EM	Checkpoint module.
CHKPNT	IA	Request for checkpoint execution.
CLAMA	DBT	Complex eigenvalue output table.
CLAMAL	DBT	Appended case control data table.
CLAMAL1	DBT	CLAMAL reduced to ØFREQ list.
CLEAR	IC	Causes all parameter values used for X-Y plots to be reset to their default values except plotter and the titles (UM-4.2).
CMASS1	IB	Scalar mass connection definition card.
CMASS2	IB	Scalar mass property and connection definition card.
CMASS3	IB	Scalar mass connection definition card (connecting scalar points).
CMASS4	IB	Scalar mass property and connection definition card (connecting scalar points).
CMETHØD	IC	Complex eigenvalue analysis method selection.

CMETHØD$	M	Indicates restart with change in complex eigenvalue analysis method selection.
CMPLEV	P	Parameter used in GKAD to indicate complex eigenvalue problem.
Cold Start	PH	A NASTRAN problem initiated at its logical beginning. A cold start will never use an Old Problem Tape but is may create a New Problem Tape for subsequent restarts.
CØLØR	IC	Selects ink color for table plotters (UM 4.1).
CØMBINE	IS	Combines sets of substructures.
CØMB1	FMSS	Substructure Combination, Step 1.
CØMB2	FMSS	Substructure Combination, Step 2.
CØMPØNENT	IS	Identifies component substructure for special processing.
CØNCT	IB	Specifies grid points and degrees of freedom for manually specified connectivities using substructuring - will be overridden by RELAS data.
CØNCT1	IB	Alternate specification of connectivities using substructuring.
CØND	EM	Conditional transfer.
CØNFIG	NP	Defines the model number of the computer system configuration for use in timing equations.
CØNM1	IB	Structural mass element connection definition card.
CØNM2	IB	Structural mass element connection definition card.
CØNNECT	IS	Defines sets for manually connected grids and releases.
CØNRØD	IB	Rod element property and connection definition card.
CØNRØD	IC	Requests structure plot for all CØNRØD elements.
CØNT	L	Continue if $[K_{oo}]$ is nonsingular.
CØNTINUE	L	Exit after last loop.
CØNTØUR	IC	Specifies displacement and stress contours to be drawn on structure plots.
CØPY	FMU	Generates a physical copy of a data block.
CØRD1C	IB	Cylindrical coordinate system definition (by grid point ID).
CØRD1R	IB	Rectangular coordinate system definition (by grid point ID).
CØRD1S	IB	Spherical coordinate system definition (by grid point ID).
CØRD2C	IB	Cylindrical coordinate system definition (by coordinates).
CØRD2R	IB	Rectangular coordinate system definition (by coordinates).
CØRD2S	IB	Spherical coordinate system definition (by coordinates).
CØSINE	IC	Indicates cosine boundary conditions for conical shell problem.

CØUPMASS	PU	Parameter used to request coupled mass.
CPBAR	PU	Selects couples mass option for BAR element.
CPHID	DBM	Complex Eigenvectors - solution set.
CPHIA	DBM	Complex eigenvector matrix, A-set.
CPHIH1	DBM	PHIHL reduced to ØFREQ list.
CPHIK	DBM	Complex eigenvector matrix, aerodynamic box points.
CPHIP	DBM	Complex Eigenvectors - physical set.
CPHIPA	DBM	Complex eigenvector matrix, PA-set.
CPHIPS	DBM	Complex eigenvector matrix, PS-set.
CPQDPLT	PU	Selects coupled mass option for QDPLT element.
CPQUAD1	PU	Selects coupled mass option for QUAD1 element.
CPQUAD2	PU	Selects coupled mass option for QUAD2 element.
CPRØD	PU	Selects coupled mass option for RØD and CØNRØD elements.
CPTRBSC	PU	Selects coupled mass option for TRBSC element.
CPTRIA1	PU	Selects coupled mass option for TRIA1 element.
CPTRIA2	PU	Selects coupled mass option for TRIA2 element.
CPTRPLT	PU	Selects coupled mass option for TRPLT element.
CPTUBE	PU	Selects coupled mass option for TUBE element.
CQDMEM	IB	Quadrilateral membrane element connection definition card.
CQDMEM1	IB	Isoparametric quadrilateral membrane element connection definition card.
CQDMEM2	IB	Quadrilateral membrane element connection definition card.
CQDPLT	IB	Quadrilateral bending element connection definition card.
CQUAD1	IB	General Quadrilateral element connection definition card.
CQUAD2	IB	Homogeneous quadrilateral element connection definition card.
CRIGD1	IB	Rigid Element Connection.
CRIGD2	IB	Rigid Element Connection.
CRIGD3	IB	General rigid element connection.
CRIGDR	IB	Rigid Rod element connection.
CRØD	IB	Rod element connection definition card.
CREDUCE	IS	Complex modal reduction request.
CSHEAR	IB	Shear panel element connection definition card.

CSLØT3	IB	Triangular slot element connection definition card for acoustic analysis.
CSLØT4	IB	Quadrilateral slot element connection definition card for acoustic analysis.
CSTM	DBS	Local coordinate system transformation matrices.
CSTM	DBT	Coordinate System Transformation Matrices.
CSTMA	DBT	Coordinate System Transformation Matrices - Aerodynamics.
CTETRA	IB	Tetrahedron element connection definition card.
CTØRDRG	IB	Toroidal ring element connection card.
CTRAPRG	IB	Trapezoidal ring element connection card.
CTRBSC	IB	Basic bending triangular element connection definition card.
CTRIA1	IB	General triangular element connection definition card.
CTRIA2	IB	Homogeneous triangular element connection definition card.
CTRIARG	IB	Triangular ring element connection card.
CTRIM	IB	Linear strain triangular element connection.
CTRMRM	IB	Triangular membrane element connection definition card.
CTRPLT	IB	Triangular bending element connection definition card.
CTRPLT1	IB	Triangular element connection.
CTRSHL	IB	Triangular shell element connection.
CTUBE	IB	Tube element connection definition card.
CTWIST	IB	Twist panel element connection definition card.
CTYPE	PU	Defines the type of cyclic symmetry.
CURVLINESYMBØL	IC	Request to connect points with lines and/or to use symbols for X-Y plots.
CVISC	IB	Viscous damper element connection definition card.
CWEDGE	IB	Wedge element connection definition card.
CYCIØ	PU	A parameter which specifies the form of the input and output data using cyclic symmetry.
CYCSEQ	PU	A parameter which specifies the procedure for sequencing the equations in the solution set using cyclic symmetry.

D	P	Parameter value used to control utility module MATGPR print of solution set matrices.
DAREA	IB	Dynamic load scale card.
DAREAS	IB	Dynamic load scale card for substructuring.
Data Block	PH	Designates a set of data (matrix, table) occupying a file. A file is "allocated" to a data block and a data block is "assigned" to a file.
Data Pool File	PH	An executive file containing the ØSCAR and any data blocks pooled by the Executive Segment File Allocator (XSFA) module. The contents of this file are described within the data pool dictionary (DPL).
DDR	FMX	User dummy module.
DDR1	FMS	Dynamic Data Recovery - Phase 1.
DDR2	FMS	Dynamic Data Recovers - Phase 2.
DDRMM	FMS	Dynamic data recovery, matrix method.
Deck	PH	1. Job Control 2. Executive Control Deck 3. Substructure Control Deck 4. Case Control Deck 5. Bulk Data Deck
DECØMØPT	P	Controls type of arithmetic used in the decomposition for frequency-response problems.
DECØMP	FMM	To decompose a square matrix into upper and lower triangular factors.
Default	PH	Many NASTRAN data items have default values supplied by the system. For example, the default value for MAXLINES is 20000.
DEFØRM	IB	Enforced element deformation definition card.
DEFØRM	IC	Enforced element deformation set selection.
DEFØRM$	M	Indicates restart with change in enforced element deformation selection.
DEFØRMATIØN	IC	Indicates subcases to be used for deformed structure plots.
DELAY	IB	Dynamic load time delay card.
Delete	IB	Delete cards from Bulk Data Deck.
DELETE	IS	Deletes individual substructure items from the SØF.
DELTAPG	DBM	Incremental load vector in Piecewise Linear Analysis Rigid Format (D-6).
DELTAQG	DBM	Incremental vector of single point constraint forces in the Piecewise Linear Analysis Rigid Format (D-6).
DELTAUGV	DBM	Incremental displacement vector in the Piecewise Linear Analysis Rigid Format (D-6).

DENSITY	IC	Density of lines for SC 4020 plotter.
DENSITY	IC	Plot tape density must be specified to plotter operator on run submittal form and will vary from one installation to another (UM-4.1).
DESTRØY	IS	Removes all data referencing a component substructure.
DESTRY	P	Appended AJJL parameter.
DET	IB	Eigenvalue analysis method option - determinant (see EIGR, EIGB, EIGC).
DET	P	Scaled determinant $\|K_{oo}\|$, see NDET.
DIAGØNAL	FMU	Strips diagonal from matrix.
DIFF	P	Parameter used in the Piecewise Linear Analysis Rigid Format (D-6).
DIFFERENTIAL STIFFNESS	IA	Selects rigid format for static analysis with differential stiffness.
DIFFSTIF	P	Parameter used in the PRTPARM module in the Differential Stiffness Rigid Format (D-4).
DIRCEAD	P	Used in printing rigid format error messages for direct complex eigenvalue analysis (D-7).
DIRECT	P	Parameter used to indicate direct formulation of dynamics problems (D-7 thru D-9).
DIRECT CØMPLEX EIGENVALUES	IA	Selects rigid format for direct complex eigenvalue analysis.
DIRECT FREQUENCY RESPØNSE	IA	Selects rigid format for direct frequency and random response.
DIRECT TRANSIENT RESPØNSE	IA	Selects rigid format for direct transient response.
DIRFRRD	P	Used in printing rigid format error messages for direct frequency response.
DIRTRD	P	Used in printing rigid format error messages for direct transient response (D-9).
DISP	IA	Displacement approach to structural analysis.
DISP	IC	Abbreviated form of DISPLACEMENT.
DISP	IS	Displacement output request.
DISPLACEMENT	IC	Request for output of displacement vector or eigenvector. (UM-2.3, 4.2).
DIT	DBT	Direct Input Table.
DIV	P	Parameter constant used in utility module PARAM.
DLØAD	IB	Dynamics load assembly definition.
DLØAD	IC	Dynamic load set solution request.

DLØAD$	M	Indicates restart with change in dynamic load set request.
DLT	DBT	Dynamic Loads Table.
DM	DBM	[D] - Rigid body transformation matrix.
DMAP	IA	Approach option (direct Matrix Abstraction Program).
DMAP Instruction	PH	A statement in the DMAP Language.
DMAP Language	PH	Data block-oriented language used by the NASTRAN Executive System to direct the sequence and flow of modules to be executed.
DMAP Loop	PH	A DMAP sequence to be repeated, initiated with a LABEL DMAP instruction and terminated by a REPT DMAP instruction.
DMAP Module	PH	A module called by means of a DMAP instruction.
DMAP Sequence	PH	A set of DMAP instructions.
DMI	IB	Direct Matrix Input (data block is defined and used by user).
DMIAX	IB	Direct Matrix Input - Axisymmetric, used in dynamic rigid formats (D-7 thru D-12).
DMIG	IB	Direct Matrix Input - used in dynamic rigid formats (D-7 thru D-12).
Doublet Lattice	PH	Subsonic aerodynamic theory.
DPD	FMS	Dynamic Pool Distributor.
DPH	M	Data Pool Housekeeper - Executive routine.
DPHASE	IB	Dynamic load phase lead card.
DSØ	P	Parameter used in functional module SDR2 in the Differential Stiffness Rigid Format (D-4).
DS1	P	Parameter used in functional module SDR2 in the Differential Stiffness Rigid Format (D-4).
DSCØ	IC	Abbreviated form of DSCØEFFICIENT.
DSCØ$	M	Indicates restart with change in differential stiffness load factor.
DSCØEFFICIENT	IC	Selects loading factor for normal modes with differential stiffness.
DSCØSET	P	Differential Stiffness coefficient set number. Used in the Differential Stiffness Rigid Format (D-13).
DSFACT	IB	Differential stiffness factor set definition card.
DSMG1	FMS	Differential Stiffness Matrix Generator - Phase 1.
DSMG2	FMS	Differential Stiffness Matrix Generator - Phase 2.
DTI	IB	Direct Table Input - means by which user may directly input any table data block.

DUMMØD1	FMX	Dummy Module-1.
DUMMOD2	FMX	Dummy Module-2.
DUMMØD3	FMX	Dummy Module-3.
DUMMOD4	FMX	Dummy Module-4.
Dummy Element	PH	Provision for user to insert additional finite element into the NASTRAN element library.
DUMP	IS	Copies the entire SØF to an external file.
Dump	PH	Printed output of contents of all, or a portion, of main memory at some point in the problem solution.
DYNAMICS	DBT	Generated by the Input File Processor (IFP) for Real Eigenvalue, Buckling, or any of the Dynamics Rigid Formats (D-3, D-5 and D-7 thru D-12).
D1JE	DBM	Downwash factors due to extra points - real.
D2JE	DBM	Downwash factors due to extra points - complex.
D1JK	DBM	Real part of downwash matrix.
D2JK	DBM	Imaginary part of downwash matrix.

E	P	Parameter value used by MATGPR to print matrices associated with extra points.
ECHØ	IC	Output request statement for echo of bulk data.
ECPT	DBT	Element Connection and Properties Table.
ECPTNL	DBT	Nonlinear subset of the ECPT. This data block is used only in the Piecewise Linear Analysis Rigid Format (D-6).
ECPTNL1	DBT	Updated version of the ECPTNL data block. Used only in the Piecewise Linear Anslysis Rigid Format (D-6).
ECPTNLPG	P	Error flag for the Piecewise Linear Analysis Rigid Format (D-6). If all elements in a piecewise linear analysis problem are linear, this error flag is set and a DMAP exit occurs.
ECT	DBT	Element Connection Table.
ECTA	DBT	Element Connection Table - Aerodynamics.
EDIT	IS	Removes data from SØF file.
EDT	DBT	Enforced Deformation Table - generated by Input File Processor.
EED	DBT	Eigenvalue Extraction Data table (D-3, D-5, D-7, D-10, D-11, D-12, D-13, D-15, A-10, A-11).
EIGB	IB	Real eigenvalue extraction data for buckling analysis (D-5).
EIGC	IB	Complex eigenvalue extraction data card (D-7 and D-10).
EIGP	IB	Complex eigenvalue pole definition card (D-7 and D-10).
EIGR	IB	Real eigenvalue extraction data for normal mode analysis (D-3, D-10 thru D-13, D-15, A-10).
EIGVS	P	Number of eigenvalues found by CEAD module.
ELEMENTS	IC	Used in element set definition for structure plot.
ELFØRCE	IC	Requests the forces in a set of structural elements or the temperature gradients and fluxes in a set of structural or heat elements in heat transfer.
ELSETS	DBT	Element plot set connection tables.
ELSETSA	DBT	Data block ELSETS, extended to include generated aerodynamic elements.
ELSTRESS	IC	Request for output of element stresses. (UM-2.3, 4.2).
END	EM	The last DMAP statement is always END.
END	IA	END is the last statement in all DMAP sequences.
ENDALTER	IA	Last card of alter packet.
ENDDATA	IB	End of Bulk Data Deck.

ENDSUBS	IS	Terminates the Substructure Control Deck.
ENERGY	IS	Modal energies output requests.
EØF	PH	End-of-File.
EPØINT	IB	Extra point definition card - used in dynamics problems only.
EPSHT	PU	Used in convergence tests for nonlinear heat transfer analysis.
EPSILØN SUB E (ε_e)	PH	Error ratio computed in SSG3. $\varepsilon_e = \varepsilon_\ell$ if the referenced load is $\{P_\ell\}$ and $\varepsilon_e = \varepsilon_o$ if the referenced load is $\{P_o\}$. See section 3.2 for mathematical definition of ε_o and ε_ℓ.
EPSIØ	PU	A parameter to test the convergence of iterated differential stiffness.
EPT	DBT	Element Property Table - output by Input File Processor.
EQAERØ	DBT	Equivalence between external points and scalar index values - Aerodynamics.
EQDYN	DBT	Equivalence of internal and external indices - dynamics.
EQEXIN	DBT	Equivalence of internal and esternal indices.
EQSS	DBS	External grid point and internal point equivalence data.
EQUIV	EM	Equivalence data blocks.
EQUIV	IS	Creates a new equivalent substructure.
Equivalence	PH	Data blocks are considered equivalenced when references to their equivalent names access the same physical data file.
ERRØR1	L	Label used when rigid format errors are detected.
ERRØR2	L	Label used when rigid format errors are detected.
ERRØR3	L	Label used when rigid format errors are detected.
ERRØR4	L	Label used when rigid format errors are detected.
ERRØR5	L	Label used when rigid format errors are detected.
ERRØR6	L	Label used when rigid format errors are detected.
ESE	IC	Request for element strain energy output.
EST	DBT	Element Summary Table.
ESTL	DBT	Element Summary Table for Linear elements. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
ESTNL	DBT	Element Summary Table for Nonlinear elements. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
ESTNL1	DBT	Updated version of the ESTNL data block. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
EVEC	DBM	Partitioning vector. D-set to A and E.

EXCEPT	IC	Forms exceptions to string of values in set declarations.
EXCLUDE	IC	Used in set definition for structure plots.
Executive	PH	1. Executive Control Deck 2. NASTRAN Executive System
Executive Control Deck	PH	One of the data decks necessary to run a problem under the NASTRAN system. This deck begins with the ID card and ends with the CEND card. Among other things, cards in this deck select the solution approach and rigid format to be used, limit the execution time, and control checkpointing and restart.
Executive System	PH	The Executive System initiates a NASTRAN problem solution via the Preface, allocates files to data blocks during problem solution, controls the sequence of the modules to be executed, and provides for problem restart capability.
EXIØ	FMSS	External input/output for the SØF.
EXIT	EM	Program termination DMAP statement.
External Sort	PH	Order of grid, scalar and extra points determined by the user's numerical order of point identification.
Extra Point	PH	A "point" which is defined on a EPØINT bulk data card. An extra point has no geometrical coordinates, defines only one degree of freedom of the model and is used only in dynamics solutions.

F	P	Parameter value used by MATGPR to print F-set matrices.
FA1	FMS	Flutter Analysis - Phase 1.
FA2	FMS	Flutter Analysis - Phase 2.
FBS	FMM	Forward and Backward Substitution
FE	P	Parameter used by MATGPR to print out FE-set matrices.
FEER	IB	Fast Eigenvalue Extraction Routine eigensolution method.
FIAT	M	File Allocation Table. Core resident executive table where data block names, status of the data blocks (assigned to a file, purged, equivalenced, etc.) and trailer for the data blocks are stored.
FILE	EM	Defines special data block characteristics to DMAP compiler.
FILE	IA	Term appearing on the checkpoint dictionary cards indicating the file number (internal) associated with a particular data block.
FILE	M	The FILE DMAP statement specifies data block characteristics such as TAPE, SAVE, and APPEND.
FILE	PH	Designates an auxiliary storage area or unit.
FILES	NP	Declares the NASTRAN permanent files as disk files.
FIND	IC	Selects parameters for structure plot.
FINIS	L	Label used in all displacement rigid format DMAPs to terminate execution of DMAP.
Finite Element	PH	Idealized unit of a structural model that represents the distributed elastic properties of a structure.
FIST	M	File Status Table. Core resident executive table where internal file names and pointers to the FIAT, pertaining only to the module being executed, are stored.
FIXED	IS	Defines set of constrained degrees of freedom for modes calculation.
FLAGS	IA	Term appearing on the checkpoint dictionary cards indicating the status of a data block (equivalenced or not).
FLFACT	IB	Specifies densities, Mach numbers and frequencies.
FLIST	DBT	Flutter Control Table.
FLØØP	P	Flutter loop counter/control.
FLSYM	IB	Structural symmetry definition card for use in hydroelastic problems.
FLUID	IC	Indicates hydroelastic harmonic degrees of freedom.
FLUTTER	IB	Defines flutter data.
FMETHØD	IC	Flutter Analysis Method Selection.

FMØDE	P	Mode number of first mode selected by user in modal dynamics formulations.
FØL	DBT	Frequency response output frequencies.
FØRCE	IB	Static load definition (vector).
FØRCE	IC	Request for output of element forces.
FØRCE1	IB	Static load definition (magnitude and two grid points).
FØRCE2	IB	Static load definition (magnitude and four grid points).
FØRCEAX	IB	Static load definition for conical shell problem.
FREEPT	IB	Defines point on a free surface of a fluid for output purposes.
FREQ	IB	Frequency list definition.
FREQ$	M	Indicates restart with change in frequencies to be solved.
FREQ1	IB	Frequency list definition (linear increments).
FREQ2	IB	Frequency list definition (logarithmic increments).
FREQRESP	P	Parameter used in SDR2 to indicate a frequency response problem.
FREQUENCY	IC	Selects the set of frequencies to be solved in frequency response problems.
FREQY	P	Selects between frequency and transient in aeroelastic response.
FRL	DBT	Frequency Response List.
FRLG	FMA	Frequency response load generator.
FRQSET	P	Used in FRRD to indicate user selected frequency set.
FRRD	FMS	Frequency and Random Response - Displacement approach.
FRRD2	FMA	Frequency response, with aerodynamic matrix capability.
FSAVE	DBT	Flutter Storage Save Table.
FSLIST	IB	Defines a free surface of a fluid in a hydroelastic problem.
Functional Module	PH	An independent group of subroutines that perform a structural analysis function.

G	PU	1. Parameter used by MATGPR to print G-set matrices. 2. Parameter used to input uniform structural damping coefficient (D-7 thru D-9).
GEI	DBT	General Element Input.
GENEL	IB	General element definition.
GEØM1	DBT	Geometric data input table - generated by the Input File Processor.
GEØM2	DBT	Connection input table - generated by the Input File Processor.
GEØM3	DBT	Static load and temperature input table - generated by the Input File Processor.
GEØM4	DBT	Displacement sets definition input table - generated by the Input File Processor.
GI	FMA	Geometry Interpolator.
GIMS	DBS	G transformation matrix for interior points from a modal reduction.
GINØ	M	General input/output. GINØ is a collection of subroutines which is the input/output control system for NASTRAN.
GINØ Buffer	PH	Storage reserved in open core for each GINØ file opened. The size of the buffer is machine dependent.
GINØ File Number	PH	File number used internally in DMAP modules to access data blocks.
GIV	IB	Eigenvalue analysis method option - Givens (see EIGR).
GKAD	FMS	General [K] Assembler - Direct.
GKAM	FMS	General [K] Assembler - Modal.
GM	DBM	$[G_m]$ - multipoint constraint transformation matrix.
GMD	DBM	$[G_m^d]$ - multipoint constraint transformation matrix used in dynamic analysis.
GNFIAT	M	Generate FIAT. The preface routine which generates the initial FIAT.
GØ	DBM	$[G_o]$ - structural matrix partitioning transformation matrix.
GØD	DBM	$[G_o^d]$ - structural matrix partitioning transformation matrix used in dynamic analysis.
GPARAM	IS	Specifies structural damping parameter.
GP1	FMS	Geometry Processor - part 1.
GP2	FMS	Geometry Processor - part 2.
GP3	FMS	Geometry Processor - part 3.
GP4	FMS	Geometry Processor - part 4.

GPCT	DBT	Grid Point Connection Table.
GPDT	DBT	Grid Point Definition Table.
GPFØRCE	IC	Requests grid point force balance output.
GPI	M	General Problem Initialization (see XGPI).
GPL	DBT	Grid Point List.
GPLA	DBT	Grid Point List - Aerodynamics.
GPLD	DBT	Grid Point List used in dynamic analysis.
GPSETS	DBT	Grid point plot sets.
GPSETSA	DBT	Data block GPSETS, extended to include generated aerodynamic grid points.
GPSP	FMS	Grid Point Singularity Processor.
GPST	DBT	Grid Point Singularity Table.
GPTT	DBT	Grid Point Temperature Table.
GPWG	FMS	Grid Point Weight Generator.
GRAV	IB	Gravity vector definition card.
GRDEQ	PU	Selects the grid point about which equilibrium will be checked.
GRDPNT	PU	Used in all displacement rigid formats to specify execution of the grid point weight generator (GPWG) by the user. A positive value references a grid point of the structural model. A value of zero indicates the origin of the basic coordinate system.
GRDSET	IB	Grid point default definition card.
GRID	IB	Grid point definition card.
Grid Point	PH	A point in Euclidean 3-dimensional space defined on a GRID bulk data card. A grid point defines 6 degrees of freedom, 3 translational and 3 rotational.
GRID PØINTS	IC	Used in set definition for structure plots.
GRIDB	IB	Grid point definition card for hydroelastic model.
GRIDF	IB	Grid point definition card for axisymmetric fluid cavity.
GRIDS	IB	Grid point definition card for slotted acoustic cavity.
GTKA	DBM	Aerodynamic transformation matrix - k-set to a-set.
GTRAN	IB	Redefines the output coordinate system grid point displacement sets.
GUST	FMA	Calculates loads due to gust.
GUST	IB	Defines stationary vertical gust.
GUST	IC	Aerodynamic gust input request.
GUSTAERØ	PU	Requests matrices used only in gust calculations to be computed.

HARMONICS	IC	Controls number of harmonics output in axisymmetric shell problems and hydroelastic problems.
HB2DD	DBM	$[B^2_{dd}]$ - Partition of heat capacity matrix.
HB2PP	DBM	$[B^2_{dd}]$ - Partition of heat capacity matrix.
HBAA	DBM	$[B_{aa}]$ - Partition of heat capabity matrix.
HBDD	DBM	$[B_{dd}]$ - Partition of heat capacity matrix.
HBFF	DBM	$[B_{ff}]$ - Partition of heat capacity matrix.
HBGG	DBM	$[B_{gg}]$ - Heat capacity matrix.
HBNN	DBM	$[B_{nn}]$ - Partition of heat capacity matrix.
HDLT	DBT	Dynamic loads table for heat transfer analysis.
Header record	PH	Initial record of a data block. Typically a header record contains only 2 BCD words, the alphanumeric name of the data block.
HEAT	IA	Selects heat transfer analysis on APProach card.
HESS	IB	Upper Hessenberg eigenvalue extraction method.
HFREQ	PU	High frequency limit for modal formulation of dynamics problems (D-10 thru D-12, A-10, A-11).
HICØRE	NP	Defines the amount of open core available to the user on the UNIVAC 1100 series.
HK2DD	DBM	$[K^2_{dd}]$ - Partition of heat conductivity matrix.
HK2PP	DBM	$[K^2_{pp}]$ - Partition of heat conductivity matrix.
HKAA	DBM	$[K_{aa}]$ - Partition of heat conductivity matrix.
HKDD	DBM	$[K_{dd}]$ - Partition of heat conductivity matrix.
HKFF	DBM	$[K_{ff}]$ - Partition of heat conductivity matrix.
HKFS	DBM	$[K_{fs}]$ - Partition of heat conductivity matrix.
HKGG	DBM	$[K_{gg}]$ - Heat conductivity matrix, including estimated linear component of radiation.
HKGGX	DBM	$[K^x_{gg}]$ - Heat conductivity matrix.
HKNN	DBM	$[K_{nn}]$ - Partition of heat conductivity matrix.
HLFT	DBS	Left side H transformation matrix from unsymmetric CREDUCE operation.
HØEF1X	DBT	Heat flux output table for CHBDY elements.
HØRG	DBS	H or G transformation matrix.
HPDØ	DBM	$\{P^o_d\}$ - Partition of dynamic load vector.
HPDT	DBM	$\{P^t_d\}$ - Partition of dynamic load vector.

HPPØ	DBM	$\{P_p^o\}$ - Partition of dynamic load vector.
HPSØ	DBM	$\{P_s^o\}$ - Partition of dynamic load vector.
HQGE	DBM	$[Q_{ge}]$ - Element radiation flux matrix for heat transfer analysis.
HRAA	DBM	$[R_{aa}]$ - Partition of radiation matrix.
HRDD	DBM	$[R_{dd}]$ - Partition of radiation matrix.
HRFF	DBM	$[R_{ff}]$ - Partition of radiation matrix.
HRGG	DBM	$[R_{gg}]$ - Radiation matrix for heat transfer analysis.
HRNN	DBM	$[R_{nn}]$ - Partition of radiation matrix.
HSLT	DBT	Static heat flux table.
HTØL	DBT	List of output time steps for heat transfer.

IC	IC	Transient analysis initial condition set selection.
ID	IA	The first card of any data deck is the identification (ID) card. The two data items on this card are BCD values.
IFP	EM	Input File Processor. The preface module which processes the sorted Bulk Data Deck and outputs various data blocks depending on the card types present in the Bulk Data Deck.
IFP1	EM	Input File Processor 1. The preface module which processes the Case Control Deck and writes the CASECC, PCDB and XYCDB data blocks.
IFP3	EM	Input File Processor 3. The preface module which processes bulk data cards for a conical shell problem.
IFP4	EM	Input File Processor 4. The preface module which processes bulk data cards for a hydroelastic problem.
IFT	FMA	Inverse Fourier transformation.
IFTM	PU	A parameter which selects the method for integration of the Inverse Fourier Transform.
IFTSKP	L	Used to skip IFT module.
IMAG	IC	Output request for real and imaginary parts of some quantity such as displacement, load, single point force of constraint element force, or stress.
IMPL	P	Parameter constant used in executive module PARAM.
INCLUDE	IC	Used in set definition for structure plots.
INERTIA	P	Used in printing rigid format error messages for Static Analysis with Inertia Relief (D-2).
INERTIA RELIEF	IA	Selects rigid format for static analysis with inertia relief.
INPT	M	A reserved NASTRAN physical file which must be set up by the user when used.
INPUT	FMU	Generates most of bulk data for selected academic problems.
Input Data Block	PH	A data block input to a module. An input data block must have been previously output from some module and may not be written on.
Input Data Cards	PH	The card input data to the NASTRAN system are in 3 sets, the Executive Control Deck, the Case Control Deck, and the Bulk Data Deck.
INPUTT1	FMU	Reads data blocks from GINØ-written user tapes.
INPUTT2	FMU	Reads data blocks from FØRTRAN-written user tapes.
INPUTT3	FMX	Auxiliary input file processor.
INPUTT4	FMX	Auxiliary input file processor.
Internal Sort	PH	Same order as external sort except when SEQGP or SEQEP bulk data cards are used to change the sequence.

INV	IB	Inverse power eigenvalue analysis option - specified on EIGR, EIGB or EIGC cards.
IRES	PU	Causes printout of residual vectors in statics rigid formats when set nonnegative via a PARAM bulk data card. (D-1, D-2, D-4, D-5, D-6).
ISTART	PU	A parameter which causes the alternate starting method to be used in transient analysis.
ITEMS	IS	Specifies data items to be copied in or out.
JUMP	EM	Unconditional transfer DMAP statement.
JUMPPLØT	P	Parameter used by structure plotter modules PLTSET and PLØT.

K2DD	DBM	$[K^{2}_{dd}]$ - Partition of direct input stiffness matrix.
K2DPP	DBM	$[K^{2d}_{pp}]$ - Direct input stiffness matrix for all physical points from bulk data deck.
K2PP	DBM	$[K^{2}_{pp}]$ - Direct input stiffness matrix for all physical points.
K2PP	IC	Selects direct input structural stiffness or thermal conductance matrices.
K2PP$	M	Indicates restart with change in direct input stiffness matrices.
K2XPP	DBM	$[K^{2x}_{pp}]$ - Direct input stiffness matrix excluding hydroelastic boundary stiffness matrix.
K4AA	DBM	$[K^{4}_{aa}]$ - Partition of structural damping matrix.
K4FF	DBM	$[K^{4}_{ff}]$ - Partition of structural damping matrix.
K4GG	DBM	$[K^{4}_{gg}]$ - Structural damping matrix generated by Structural Matrix Assembler
K4MX	DBS	Structural damping matrix.
K4NN	DBM	$[K^{4}_{nn}]$ - Partition of structural damping matrix.
KAA	DBM	$[K_{aa}]$ - A-set stiffness matrix.
KAAB	DBM	$[\overline{K}_{aa}]$ - Partition of stiffness matrix.
KBFS	DBM	$[K^{b}_{fs}]$ - Partition of combination of elastic stiffness matrix matrix and differential stiffness matrix.
KBFL	DBM	$[K_{b,f\ell}]$ - Hydroelastic boundary stiffness matrix.
KBLL	DBM	$[K^{b}_{\ell\ell}]$ - Combination of elastic stiffness and differential stiffness used in static analysis with differential stiffness.
KBSS	DBM	$[K^{b}_{ss}]$ - Partition of combination of stiffness matrix and differential stiffness matrix.
KDAA	DBM	$[K^{d}_{aa}]$ - Partition of differential stiffness matrix.
KDAAM	DBM	$-[K^{d}_{aa}]$ - Differential stiffness matrix used in formulation of buckling problems (D-5).
KDAMP	PU	-1 for structural damping, +1 for viscous.
KDD	DBM	$[K_{dd}]$ - Stiffness matrix used in direct formulation of dynamics problems (D-7 thru D-9).
KDEK2	P	Parameter indicating equavalence of KDD and K2DD.
KDEKA	P	Parameter indicating equavalence of KDD and KAA.
KDFF	DBM	$[K^{d}_{ff}]$ - Partition of differential stiffness matrix.
KDFS	DBM	$[K^{d}_{fs}]$ - Partition of differential stiffness matrix.
KDGG	DBM	$[K^{d}_{gg}]$ - Differential stiffness matrix prepared by Differential Stiffness Matrix Generator.
KDNN	DBM	$[K^{d}_{nn}]$ - Partition of differential stiffness matrix.

KDSS	DBM	$[K^{d}_{ss}]$ - Partition of differential stiffness matrix.
KE	PH	Flutter analysis method.
KEF	DBM	$[K_{ff}]$ - Partition of stiffness matrix.
KFS	DBM	$[K_{fs}]$ - Partition of stiffness matrix.
KGG	DBM	$[K_{gg}]$ - Stiffness matrix generated by Structural Matrix Assembler.
KGGL	DBM	$[K^{\ell}_{gg}]$ - Stiffness matrix for linear elements. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
KGGLPG	P	Purge flag for KGGL matrix. If set to -1, it implies that there are no linear elements in the structural model. (D-6).
KGGNL	DBM	$[K^{n\ell}_{gg}]$ - Stiffness matrix for the nonlinear elements. Used in the Piecewise Linear Analysis Rigid Format only.
KGGSUM	DBM	Sum of KGGNL and KGGL. Used in the Piecewise Linear Analysis Rigid Format only. (D-6).
KGGX	DBM	$[K^{x}_{gg}]$ - Stiffness matrix excluding general elements.
KGGXL	DBM	$[K^{x\ell}_{gg}]$ - Stiffness matrix for linear elements (excluding general elements). Used in the Piecewise Linear Rigid Format only. (D-6).
KGGY	DBM	$[K^{y}_{gg}]$ - Stiffness matrix of general elements.
KHH	DBM	$[K_{hh}]$ - Stiffness matrix used in modal formulation of dynamics problems (D-10 thru D-12).
KINDEX	PU	A parameter which specifies a single value of the harmonic index using cyclic symmetry.
KLL	DBM	$[K_{\ell\ell}]$ - Stiffness matrix used in solution of problems in static analysis (D-1, D-2, D-4, D-5, D-6).
KLR	DBM	$[K_{\ell r}]$ - Partition of stiffness matrix.
KMAX	PU	A parameter which specifies the maximum value of the harmonic index using cyclic symmetry.
KMTX	DBS	Stiffness matrix.
KNN	DBM	$[K_{nn}]$ - Partition of stiffness matrix.
KØA	DBM	$[K_{oa}]$ - Stiffness matrix partition.
KØØ	DBM	$[K_{oo}]$ - Partition of stiffness matrix.
KRR	DBM	$[K_{rr}]$ - Partition of stiffness matrix.
KSS	DBM	$[K_{ss}]$ - Partition of stiffness matrix.
KXHH	DBM	Total modal stiffness matrix - h-set.

L	P	Parameter value used by MATGPR to print L-set matrices.
LABEL	EM	DMAP location.
LABEL	IC	Defines third line of titles to be printed on each page of printer output. Also used on plots.
LABEL	IC	Requests identification of grid points and/or elements on structure plot.
LAMA	DBT	Real eigenvalues.
LAMS	DBS	Eigenvalue data from modal reduce operation.
LAMX	FMU	Edit or generate data block, LAMA.
LBLi	L	A label used in displacement approach rigid formats where i represents one or more characters used to form unique labels.
LBLL	DBM	$[L^{b}_{\ell\ell}]$ - Lower triangular factor of $[K^{b}_{\ell\ell}]$.
LEFT TICS	IC	Request for tic marks to be plotted on left hand edge of frame for X-Y plots.
LFREQ	PU	Low frequency limit for modal formulation of dynamics problems (D-10 thru D-12).
LGPWG	L	Label used in conjunction with the Grid Point Weight Generator.
LINE	IC	Number of data lines printed per page of printer output. It should be set to 50 for 11 x 17 inch paper, and to 35 for 8 1/2 x 17 inch paper.
LIST	IA	Used to list the problem deck from UMF or copy the problem deck from UMF onto NUMF and list it.
LLL	DBM	$[L_{\ell\ell}]$ - Lower triangular factor of $[K_{\ell\ell}]$.
LMØDES	PU	Number of lowest modes for modal formulation of dynamics problems (D-10 thru D-12).
LMTX	DBS	Decomposition product of REDUCE operation.
LØAD	IB	Statis load combination definition.
LØAD	IC	Selects statis structural loading condition or heat power and/or flux.
LØADC	IB	Defines loading conditions for static analysis using sybstructuring.
LØAD$	M	Indicates restart with change in static load set request.
LØAP	DBS	Load set identification numbers for appended load vectors.
LØDS	DBS	Load set identification numbers.
LØGARITHMIC	IC	Requests logarithmic scales for X-Y plots.
LØGPAPER	IC	Requests logarithmic paper for X-Y plots.
LØØ	DBM	$[L_{oo}]$ - Lower triangular factor of $[K_{oo}]$.

LØØP1$	M	Indicates looping problem in modified restart. (PM-4.3.7.1)
LØØPBGN	L	Signifies the beginning of the Piecewise Linear Analysis Rigid Format DMAP Loop. (D-6).
LØØPEND	L	Signifies the end of the Piecewise Linear Analysis Rigid Format DMAP loop. (D-6).
LØØP$	M	Indicates looping problem in modified restart. (PM-4.3.7.1)
LØØPTØP	L	Top of rigid format loop.
LØWER TICS	IC	Request for tic marks to be plotted on bottom edge of frame for X-Y plots.
LSING	L	Used if $[K_{oo}]$ is singular.
LUSET	P	Order of USET.
LUSETA	P	Number of degrees of freedom in the pa displacement set.
LUSETD	P	Order of USETD.

M	P	Parameter value used by MATGPR to print M-set matrices.
M2DD	DBM	$[M^2_{dd}]$ - Partition of direct input mass matrix.
M2DPP	DBM	$[M^{2d}_{pp}]$ - Direct input mass matrix for all physical points from Bulk Data Deck.
M2PP	DBM	$[M^2_{pp}]$ - Direct input massmatrix for all physical points.
M2PP	IC	Direct input mass matrix selection.
M2PP$	M	Indicates restart with change in direct input mass matrices.
MAA	DBM	$[M_{aa}]$ - Partition of mass matrix.
MACH	PU	Velocity divided by speed of sound.
MASS	IB	Eigenvector normalization option - used on EIGR card.
MAT1	IB	Material definition card for isotropic material.
MAT2	IB	Material definition card for anisotropic material.
MAT3	IB	Material definition card for orthotropic material.
MAT4	IB	Thermal material definition card for isotropic material.
MAT5	IB	Thermal material definition card for anisotropic material.
MATGPR	FMU	Utility module for printing matrices with Grid Point Identification.
MATPØØL	DBT	Grid point oriented direct input matrix data pool, output by Input File Processor and used by functional module MTRXIN.
MATPRN	FMU	Utility module for printing matrices.
MATPRT	FMU	Utility module for printing matrices with geometric grid points.
Matrix Control Block	PH	A seven word array, the first word is a GINØ file number, and words 2 through 7 comprise a matrix trailer.
Matrix Data Block	PH	A data block is classified as a matrix if and only if it is generated by one of the NASTRAN matrix packing routines, PACK or BLDPK.
Matrix Decomposition	PH	A factorization of a matrix K so that K = LU where L is a unit lower triangular matrix and U is an upper triangular matrix.
MATS1	IB	Specifies table references for stress-dependent material properties.
MATT1	IB	Specifies table references for temperature-dependent isotropic material properties.
MATT2	IB	Specifies table references for temperature-dependent anisotropic material properties.
MATT3	IB	Specifies table references for temperature-dependent orthotropic material properties.
MATT4	IB	Specifies table references for temperature-dependent isotropic, thermal material properties.

MATT5	IB	Specifies table references for temperature-dependent, anisotropic, thermal material properties.
MAX	IB	Eigenvector normalization option - used on EIGR, EIGB and EIGC cards.
MAXIMUM DEFØRMATIØN	IC	Indicates scale for deformed structure plots.
MAXIT	PU	Limits maximum number of iterations in nonlinear heat transfer analysis.
MAXLINES	IC	Maximum printer output line count - default value is 20000.
MCE1	FMS	Multipoint Constraint Eliminator - part 1.
MCE2	FMS	Multipoint Constraint Eliminator - part 2.
MDD	DBM	$[M_{dd}]$ - Mass matrix used in direct formulation of dynamics problems (D-7 thru D-9).
MDEMA	P	Parameter indicating equivalence of MDD and MAA.
MDLCEAD	P	Used in printing rigid format error messages for modal complex eigenvalue analysis (D-10).
MDLFRRD	P	Used in printing rigid format error messages for modal frequency response (D-11).
MDLTRD	P	Used in printing rigid format error messages for modal transient response (D-12).
MEF1	DBT	Modal element forces, Sort 1 for ØFP.
MEF2	DET	Modal element forces, Sort 2 for ØFP.
MERGE	FMM	Matrix merge functional module.
MES1	DBT	Modal element stresses, Sort 1 for ØFP.
MES2	DBT	Modal element stresses, Sort 2 for ØFP.
METHØD	IC	Selects method for real eigenvalue analysis.
METHØD	IS	Identifies EIGR Bulk Data card.
METHØD$	M	Indicates restart with change in eigenvalue extraction procedures.
MFF	DBM	$[M_{ff}]$ - Partition of mass matrix.
MGG	DBM	$[M_{gg}]$ - Mass matrix generated by Structural Matrix Assembler.
MHH	DBM	$[M_{hh}]$ - Mass matrix used in modal formulation of dynamics problems (D-10 thru D-12).
MI	DBM	[m] - Modal mass matrix.
MIND	P	Minimum diagonal term of $[U_{oo}]$.
MKAERØ1	IB	Provides table of Mach numbers and reduced frequencies (k).
MKAERØ2	IB	Provides list of Mach numbers (m) and reduced frequencies (k).

MLL	DBM	$[M_{\ell\ell}]$ - Partition of mass matrix.
MLR	DBM	$[M_{\ell r}]$ - Partition of mass matrix.
MMTX	DBS	Mass matrix.
MNN	DBM	$[M_{nn}]$ - Partition of mass matrix.
MØA	DBM	$(M_{oa}]$ - Partition of mass matrix.
MØDA	FMX	User dummy module.
MØDACC	FMS	Mode Acceleration Output Reduction Module.
MØDACC	PU	A parameter to use the mode acceleration method.
MØDAL	IC	Requests structure plots of mode shapes.
MØDAL	P	Indicates modal as opposed to direct formulation of dynamics.
MØDAL CØMPLEX EIGENVALUES	IA	Selects rigid format for modal complex eigenvalue analysis.
MØDAL FREQUENCY RESPØNSE	IA	Selects rigid format for modal frequency and random response.
MØDAL TRANSIENT RESPØNSE	IA	Selects rigid format for modal transient response.
MØDB	FMX	User dummy module.
MØDC	FMX	User dummy module.
MØDCØM	NP	Defines an array for module communications.
MØDEL	IC	Indicates model number of structure plotter.
MØDES	IA	Selects rigid format for normal mode analysis.
MØDES	IC	Duplicates output requests for eigenvalue problems.
MØDES	IS	Modes output request.
MØDES	P	Used in printing rigid format error messages for normal modes analysis (D-3).
Modified Restart	PH	Restarting (see Restart) a NASTRAN problem and redirecting its solution by changing the rigid format and/or selected input data.
Module	PH	A logical group of subroutines which performs a defined function.
MØMAX	IB	Conical shell moment definition card.
MØMENT	IB	Static moment load definition (vector).
MØMENT1	IB	Static moment load definition (magnitude and two grid points).
MØMENT2	IB	Static moment load definition (magnitude and four grid points).
MØØ	DBM	$[M_{oo}]$ - Partition of mass matrix.
MPC	IB	Multipoint constraint definition.

MPC	IC	Selects set of multipoint constraings for structural displacement or heat transfer boundary temperature relationships.
MPC$	M	Indicates restart with change in multipoint constraints.
MPCADD	IB	Multipoint constraint set definition.
MPCAX	IB	Conical shell multipoint constraint definition.
MPCFØRCES	IC	Requests multipoint forces of constraint at a set of points in Rigid Formats D-1, 2, 3, 14, 15.
MPCF1	P	No multipoint constraints.
MPCF2	P	No change in multipoint constraints for loop.
MPCS	IB	Specifies multipoint constraints for substructuring.
MPHIPA1	DBT	Eigenvectors, PA-set, SØRT1.
MPHIPA2	DBT	Eigenvectors, PA-set, SØRT2.
MPL	PH	Module properties list. The MPL defines each DMAP module's name, the number of input, output and scratch files required and the parameter list. It is used by the preface module XGPI to generate the ØSCAR.
MPT	DBT	Material Properties Table - output by Input File Processor.
MPY	M	Parameter constant used in executive module PARAM.
MPYAD	FMM	Performs multiply-add matrix operation.
MQP1	DBT	Constraint forces, PA-set, SØRT1.
MQP2	DBT	Constraint forces, PA-set, SØRT2.
MR	DBM	$[M_r]$ - Rigid body mass matrix.
MREDUCE	IS	Real modal reduction request.
MRR	DBM	$[M_{rr}]$ - Partition of mass matrix.
MTRXIN	FMS	Selects direct input matrices for current loop in dynamics problems (D-7 thru D-12).
MX	IC	Indicates negative x-axis direction for structure plot.
MXHH	DBM	Total modal mass matrix - h-set.
MY	IC	Indicates negative y-axis direction for structure plot.
MZ	IC	Indicates negative z-axis direction for structure plot.

N	M	Used in parameter section of DMAP statement. Indicates that parameter may not be given an initial value with a PARAM bulk data card.
N	P	Parameter value used by MATGPR to print N-set matrices.
NAME	IS	Specifies Phase 1 basic substructure name or names the resulting substructure in Phase 2.
NASTPLT	IC	Requests NASTRAN general purpose plotter.
NASTRAN	M	Acronym for NAsa STRuctural ANalysis program.
NASTRAN Data Deck	PH	The composite deck consisting of the Executive Control Deck, the Case Control Deck, the Substructure Control Deck, and the Bulk Data Deck. This deck, when preceeded by any necessary operating system control cards, constitutes the complete card input for a NASTRAN run (PM-5).
NCHECK	IC	Requests significant digits to indicate numerical accuracy of element stress and force computations.
NDET	P	Power of 10 used to scale parameter DET.
NE	P	Parameter value used by MATGPR to print out NE-set matrices.
NEIGV	P	Number of real eigenvalues found.
NEVER	P	Set to +1 by a DMAP PARAM statement in the Piecewise Linear Analysis Rigid Format (D-6).
New Problem Tape	PH	See Problem Tape.
NJ	P	Number of degrees of freedom in the j displacement set.
NK	P	Number of degrees of freedom in the k displacement set.
NLFT	DBT	Nonlinear function table.
NLLØAD	IC	Requests nonlinear load output for transient problems.
NLØAD	PU	A parameter of static loading conditions using cyclic symmetry.
NMAX	IS	Identifies number of lowest frequency modes for retained modal coordinates.
NØ	IA	Option used on CHKPNT card, indicates that no checkpoint is desired.
NØA	P	Indicates no constraints applied to structural model.
NØABFL	P	No fluid-structure interface in a hydroelastic problem.
NØB2PP	P	No direct input damping matrix.
NØBGG	P	No viscous damping matrix (D-7 thru D-9).
NØCEAD	P	Used to skip CEAD module when not required.
NØCSTM	P	No Coordinate System Transformation Matrices.
NØD	P	No output request that is limited to independent degrees of freedom.

NØDJE	PU	Positive value selects D1JE and D2JE from INPUTT2.
NØDLT	P	No Dynamic Loads Table.
NØEED	P	No Eigenvalue Extraction Data.
NØELMT	P	No elements are defined.
NØFL	P	No fluid-structure interface and no fluid gravity in a hydroelastic problem.
NØFRL	P	No Frequency Response List.
NØFRY	P	Used by aeroelastic response for transient solution.
NØGENEL	P	No general elements.
NØGPDT	P	No Grid Point Definition Table.
NØGPST	P	No grid point singularity table.
NØGRAV	P	No gravity loads.
NØGUST	P	No gust input.
NØH	L	Used to skip modal output.
NØH	P	Used to skip modal output.
NØK2PP	P	No direct input stiffness matrices.
NØK4GG	P	No structural damping matrix.
NØKBFL	P	No fluid gravity or structural interface in a hydroelastic problem.
NØL	P	No independent degrees of freedom.
NØLIN1	IB	Nonlinear transient dynamic load set definition card.
NØLIN2	IB	Nonlinear transient dynamic load set definition card.
NØLIN3	IB	Nonlinear transient dynamic load set definition card.
NØLIN4	IB	Nonlinear transient dynamic load set definition card.
NØLØØP$	M	Indicates restart of problem without DMAP loop. (PM-4.3.7.1).
NØM2DPP	P	No direct input mass matrix from Bulk Data Deck.
NØM2PP	P	No direct input mass matrices.
NØMGG	P	If functional module SMA2 generates a zero mass matrix, NOMGG is set to -1. Otherwise, it is set to +1.
NØMØD	P	Mode acceleration data recovery not requested.
NØNCUP	P	Indicates diagonal MHH, BHH, and KHH allowing uncoupled solution in TRD and FRRD.
NØNE	IC	Override for output and bulk data deck echo requests.
NØNLIFT	P	No nonlinear function table.

NØNLINEAR	IC	Selects nonlinear load for transient problems.
NØNLINEAR STATIC HEAT TRANSFER ANALYSIS	IA	Selects rigid format for nonlinear static analysis using heat transfer.
NØNLSTR	P	No stress output request for nonlinear elements (D-6).
NØP	M	Parameter constant used in executive module PARAM.
NØP	P	No output request involving dependent degrees of freedom or stresses.
NØPF	L	Skip load calculations in transient aeroelastic response.
NØPSDL	P	No Power Spectral Density List.
NØRMAL MØDES	IA	Selects rigid format for normal mode analysis.
NØRMAL MØDES ANALYSIS WITH CYCLIC SYMMETRY	IA	Selects rigid format for normal modes analysis using cyclic symmetry.
NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS	IA	Selects rigid format for normal modes analysis with differential stiffness effects.
NØRN	P	No random requests.
NØSET	P	No dependent coordinates.
NØSIMP	P	No structural elements are defined.
NØSØRT2	P	No request for output sorted by point number or element number.
NØSR	P	No single-point constraints or free body supports.
NØT	M	Parameter constant used in utility module PARAM.
NØTFL	P	No Transfer Function List.
NØTRL	P	No Transient Response List.
NØUE	P	No extra points introduced for dynamic analysis.
NØUE1	L	No extra points.
NØXYCBD	P	-1 indicates no XY output requests.
NØXYØUT	L	No XY-output requests.
NØXYPL	P	No XY-plot requests.
NØXYPLTT	L	No XY-plot requests.
NPLALIM	P	Set by module PLA1 as the Piecewise Linear Analysis Rigid Format DMAP loop counter. (D-6)
NPTP	M	New Problem Tape - a reserved NASTRAN physical file which must be set up by the user when used.

NSEGS	PU	A parameter of identical segments in the structural model using cyclic symmetry.
NSIL	P	Order of SIL table.
NSIL1	P	Number of grid and scalar points.
NSKIP	P	Locate current boundary conditions in Case Control.
NT	PU	A parameter to limit the cumulative number of iterations for the static analysis with differential stiffness loops.
NUMF	IA	Used to add problem deck to NUMF, list it and punch UMF card.
NUMF	M	New User Master File - used only when operating NASTRAN as a user master file editor. (See UMFEDIT). A reserved NASTRAN physical file which must be set up by the user when used.
NVECTS	P	Number of eigenvectors found.

Ø	P	Parameter value used by MATGPR to print Ø-set matrices.
ØBEF1	DBT	Element force output table (D-5).
ØBES1	DBT	Element stress output table (D-5).
ØBQG1	DBT	Forces of single point constraint output table (D-5).
ØCEIGS	DBT	Complex eigenvalue summary table (D-7, D-10).
ØCPHIP	DBT	Complex eigenvector output table (D-7, D-10).
ØCPHIPA	DBT	Complex eigenvector output table, aeroelastic.
ØEF1	DBT	Element force output table (D-1, D-2, D-4, D-5, D-6).
ØEF2	DBT	Element force output table - SØRT2 (D-9, D-12).
ØEFB1	DBT	Element force output table (D-4).
ØEFC1	DBT	Element force output table - complex (D-7, D-8, D-10, D-11).
ØEFC2	DBT	Element force output table - complex - SØRT2 (D-8, D-11).
ØEIGS	DBT	Real Eigenvalue summary output table (D-3, D-5).
ØES1	DBT	Element stress output table (D-1, D-2, D-4, D-5, D-6).
ØES2	DBT	Element stress output table - SØRT2 (D-9, D-12).
ØESB1	DBT	Element stress output table (D-4).
ØESC1	DBT	Element stress output table - complex (D-7, D-8, D-10, D-11).
ØESC2	DBT	Element stress output table - complex - SØRT2 (D-8, D-11).
ØFP	FMS	Output File Processor.
ØFREQ	IC	Output Frequency set.
ØFREQUENCY	IC	Selects a set of frequencies to be used for output requests in frequency response problems (default is all frequencies) or flutter velocities.
ØGPST	DBT	Grid point singularity output table.
ØGPWG	DBT	Grid point weight generator output table.
ØLDBØUND	IS	Flag to identify rerunning problem with previously defined boundary set.
ØLDMØDES	IS	Flag to identify rerunning problem with previously computed modal data.
Old Problem Tape	PH	See Problem Tape.
ØLØAD	IC	Request for output of external load vector.
ØLØAD	IS	Applied load output request.
ØMIT	IB	Omitted coordinate definition card.

ØMIT	P	Indicates no omitted coordinates.
ØMIT1	IB	Omitted coordinate definition card.
ØMITAX	IB	Omitted coordinate definition card for conical shell problems.
ØNLES	DBT	Output table for nonlinear element stresses (D-6).
Open Core	PH	A contiguous block of working storage defined by a labeled common block, whose length is a variable determine by the NASTRAN executive routine CØRSZ.
ØPG1	DBT	Static load output table (D-1, D-2, D-4, D-5, D-6).
ØPHID	DBT	Output table for complex eigenvectors - solution set (D-7).
ØPHIG	DBT	Eigenvector output table (D-3, D-5).
ØPHIH	DBT	Output table for complex eigenvectors - solution set (D-10).
ØPNL1	DBT	Output table for nonlinear loads - solution set, SØRT1 (D-9, D-12).
ØPNL2	DBT	Output table for nonlinear loads - solution set, SØRT2 (D-9, D-12).
ØPP1	DBT	Dynamic load output table (D-9, D-12).
ØPP1	DBT	Aerodynamic transient load output table, sort 1.
ØPP2	DBT	Dynamic load output table - SØRT2 (D-9, D-12).
ØPPC1	DBT	Dynamic load output table - SØRT1, complex (D-8, D-11).
ØPPC2	DBT	Dynamic load output table - SØRT2, complex (D-8, D-11).
ØPT	PU	Controls the type of multipoint constraint output.
ØPTIØNS	IS	Defines matrix types.
ØPTP	M	Old Problem Tape - a reserved NASTRAN physical file which must be set up by the user when used.
ØQBG1	DBT	Forces of single-point constraint output table (D-4).
ØQG1	DBT	Single-point constraint force output table (D-1, D-2, D-4, D-5, D-6).
ØQP1	DBT	Single-point constraint force output table SØRT1 (D-9, D-12).
ØQP2	DBT	Single-point constraint force output table SØRT2 (D-9, D-12).
ØQPC1	DBT	Single-point constraint force output table - complex, SØRT1 (D-7, D-8, D-10, D-11).
ØQPC2	DBT	Single-point constraint force output table - complex, SØRT2 (D-7, D-8, D-10, D-11).
ØQPCA1	DBT	Complex constraint force output table, aeroelastic.
ØR	M	Parameter constant used in executive module PARAM.

ØRIGIN	IC	Locates origin for structure plot.
ØRTHØGRAPHIC	IC	Specifies orthographic projection for structure plot.
ØSCAR	PH	Operation sequence control array. Executive table residing on the Data Pool File which contains the sequence of operations to be executed for a problem solution. The ØSCAR is an expansion of a DMAP sequence, either input by the user or extracted from a rigid format, in internal format.
ØTIME	IC	Selects a set of times to be used for output requests in transient analysis problems (default is all times).
ØUBGV1	DBT	Displacement vector output table (D-4).
ØUDV1	DBT	Displacement vector output table - solution set, SØRT1 (D-9).
ØUDV2	DBT	Displacement vector output table - solution set, SØRT2 (D-9).
ØUDVC1	DBT	Displacement vector output table - solution set, SØRT1, complex (D-8, D-11).
ØUDVC2	DBT	Displacement vector output table - solution set, SØRT2, complex (D-8, D-11).
ØUGV1	DBT	Displacement output table (D-1, D-2, D-4, D-5, D-6).
ØUHV1	DBT	Displacement vector output table - solution set, SØRT1 (D-12).
ØUHV2	DBT	Displacement vector output table - solution set, SØRT2 (D-12).
ØUHVC1	DBT	Displacement vector output table - solution set, SØRT1, complex (D-11).
ØUHVC2	DBT	Displacement vector output table - solution set, SØRT2, complex (D-11).
ØUPV1	DBT	Displacement vector output table - SØRT1 (D-9, D-12).
ØUPV2	DBT	Displacement vector output table - SØRT2 (D-9, D-12).
ØUPVC1	DBT	Displacement vector output table - complex, SØRT1 (D-8, D-11).
ØUPVC2	DBT	Displacement vector output table - complex, SØRT2 (D-8, D-11).
ØUTPUT	FMX	Auxiliary output file processor.
ØUTPUT	IC	Marks beginning of printer output request packet - optional.
ØUTPUT	IS	Specifies optional output results.
Output Data Block	PH	A data block output from a module. A data block may be output from one and only one module. Having been output, it may be used as an input data block as many times as necessary.
ØUTPUT1	FMU	Writes data blocks on GINØ-written user tapes.
ØUTPUT2	FMU	Writes data blocks on FØRTRAN-written user tapes.
ØUTPUT3	FMU	Punches matrices on DMI cards.
ØUTPUT4	FMX	Auxiliary output file processor.

P	P	Parameter value used in MATGPR to print P-set matrices.
P	PH	Flutter analysis method.
Packed Format	PH	A matrix is said to be in packed format if only the nonzero elements of the matrix are written.
PAERØ1	IB	Aerodynamic Panel Property.
PAERØ2	IB	Properties of aerodynamic bodies.
PAERØ3	IB	Defines Mach Box geometries.
PAERØ4	IB	Properties of strips (strip theory).
PAERØ5	IB	Properties of strips (piston theory).
PAPER SIZE	IC	Selects paper size for structure plots using table plotters.
PAPP	DBS	Appended load vectors.
PARAM	FMU	Manipulates parameter values.
PARAM	IB	Parameter definition card.
Parameter	PH	A FØRTRAN variable communicated to a DMAP module by the NASTRAN Executive System through blank common. A parameter's position in the DMAP calling sequence to a module corresponds to the position of the parameter in blank common at module execution time.
PARAML	FMU	Selects parameters from a user input matrix or table.
PARAMR	FMU	Performs specified operations on real or complex parameters.
PARTN	FMM	Matrix partitioning functional module.
PARTVEC	FMX	User dummy module.
PASSWØRD	IS	SØF file protection.
PBAR	IB	Bar property definition card.
PBL	DBM	A scalar multiple of the PL load vector. Used only in the Differential Stiffness Rigid Format (D-4).
PBS	DBM	A scalar multiple of the PL load vector. Used only in the Differential Stiffness Rigid Format (D-4).
PCDB	DBT	Plot control data block (table for use with structure plotter functional module PLTSET).
PCØNEAX	IB	Conical shell element property definition card.
PCPHIPA	DBT	Complex displacement plot file.
PDAMP	IB	Scalar damper property definition card.
PDF	DBM	Dynamic load matrix for frequency analysis.
PDT	DBM	Linear dynamic load matrix for transient analysis.

PDUMi	IB	Property definition card for dummy elements 1 through 9.
PELAS	IB	Scalar elastic property definition card.
PEN	IC	Selects pen size for structure plots using table plotters.
PENSIZE	IC	Selects pen size for X-Y plots using table plotters.
PERSPECTIVE	IC	Specifies perspective projection for structure plots.
PFILE	P	Parameter used by PLØT module.
PG	DBM	Incremental load vector used in Piecewise Linear Analysis (D-6).
PG	DBM	Statics load vector generated by SSG1.
PG1	DBM	Static load vector for Piecewise Linear Analysis (D-6).
PGG	DBM	Appended static load vector (D-1, D-2).
PGV1	DBM	Matrix of successive sums of incremental load vectors used only in Piecewise Linear Analysis Rigid Format (D-6).
PHASE	IC	Requests magnitude and phase form of complex quantities.
Phase 1	PH	An operation to create matrices and load vectors for substructuring analysis.
Phase 2	PH	An operation to combine and reduce matrices and load vectors for substructuring analysis.
Phase 3	PH	An operation to recover detailed data reduction for substructuring analysis.
PHBDY	IB	Boundary element property definition card for heat transfer analysis.
PHF	DBM	Total frequency response loads, modal.
PHFI	DBM	Non-gust frequency response loads, modal.
PHIA	DBM	$[\phi_a]$ - Real eigenvectors - solution set.
PHIAH	DBM	Eigenvectors, A-set.
PHID	DBM	$[\phi_a]$ - Complex eigenvectors - solution set, direct formulation.
PHIDH	DBM	$[\phi_{dh}]$ - Transformation matrix between modal and physical coordinates.
PHIG	DBM	$[\phi_g]$ - Real eigenvectors.
PHIH	DBM	$[\phi_h]$ - Complex eigenvectors - solution set, modal formulation.
PHIHL	DBM	Appended complex mode shapes - h-set.
PHIK	DBM	Eigenvectors, aerodynamic box points.
PHIL	DBS	Left side eigenvector matrix from unsymmetric CREDUCE operation.
PHIP	DBM	Eigenvectors, P-set.
PHIPA	DBM	Eigenvectors, PA-set.

PHIPS	DBM	Eigenvectors, PS-set.
PHIS	DBS	Eigenvector matrix.
Physical Points	PH	Grid points and extra scalar points introduced for dynamic analysis.
PIECEWISE LINEAR	IA	Selects rigid format for piecewise linear analysis.
Pivot Point	PH	The first word of each record of the GPCT and ECPT data blocks is called the pivot point.
PJUMP	P	Used to skip deformed plots.
PK	PH	Flutter analysis method.
PKF	DBML	Forces an aerodynamic boxes, as a function of frequency.
PL	DBM	$\{P_\ell\}$ - Partition of load vector.
PLA	P	Used in printing rigid format error messages for Piecewise Linear Analysis (D-6).
PLA1	FMS	Piecewise Linear Analysis - phase 1.
PLA2	FMS	Piecewise Linear Analysis - phase 2.
PLA3	FMS	Piecewise Linear Analysis - phase 3.
PLA4	FMS	Piecewise Linear Analysis - phase 4.
PLACØUNT	P	Loop counter in Piecewise Linear Analysis (D-6).
PLALBL2A	L	Used in the Piecewise Linear Analysis Rigid Format only. (D-6)
PLALBL3	L	Used in the Piecewise Linear Analysis Rigid Format only. (D-6)
PLALBL4	L	Used in the Piecewise Linear Analysis Rigid Format only. (D-6)
PLCØEFFICIENT	IC	Selects the coefficient set for Piecewise Linear Analysis problems.
PLFACT	IB	Piecewise Linear Analysis factor definition card.
PLI	DBM	$\{P_\ell^i\}$ - Partition of inertia relief load vector.
PLIMIT	IB	Property Optimization limits.
PLØAD	IB	Pressure load definition (D-1, D-2, D-4, D-5, D-6).
PLØAD2	IB	Element pressure loading for two-dimensional elements (D-1, D-2, D-4, D-5, D-6).
PLØT	FMS	Structure plot generator.
PLØT	IC	Execution card for structure plotter.
PLØT	IS	Phase 2 undeformed plot request.
PLØT$	M	Indicates restart with a structure plot request.

Plot Tapes	PH	Magnetic tapes containing NASTRAN generated data to drive offline plotters. PLT1 is the name of the BCD plot tape and PLT2 is the name of binary plot tape.
PLØTEL	IB	Plot element definition card used to defind convenient reference lines in structure plots.
PLØTTER	IC	Used to select one of several available plotters for structure plotter.
PLØTX1	DBT	Messages from plot module concerning action taken by the structure plotter in processing undeformed structure plots.
PLØTX2	DBT	Messages from plot module concerning action taken by the structure plotter in processing deformed structure plots.
PLØTX3	DBT	Deformed plot messages for aeroelastic.
PLSETNØ	P	Set number on a PLFACT bulk data card chosen by the user in his case control deck. Used only in Piecewise Linear Analysis (D-6).
PLT1	M	A reserved NASTRAN physical file which must be set up by the user when used - see Plot Tapes.
PLT2	M	A reservec NASTRAN physical file which must be set up by the user when used - see Plot Tapes.
PLTFLG	P	Parameter used by PLØT module.
PLTMRG	FMSS	Substructure plot set data merge.
PLTPAR	DBT	Plot control table.
PLTPARA	DBT	Plot control table PLTPAR, with aeroelastic data.
PLTS	DBS	Plot sets and other data required for Phase 2 plotting.
PLTSET	FMS	Plot set definition processor.
PLTSETA	DBT	Set definitions for aerodynamic plots.
PLTSETX	DBT	Error messages for plot sets.
PLTTRAN	FMS	Prepares data blocks for acoustic analysis plots.
PLTTRAN	FMS	Transforms grid point definition tables for scalar points into a format for plotting.
PMASS	IB	Scalar mass property definition card.
PNLD	DBM	$\{P_d^n\}$ - Nonlinear loads in direct transient problem.
PHLH	DBM	$\{P_h^n\}$ - Nonlinear loads in modal transient problem.
PØ	DBM	$\{P_o\}$ - Partition of load vector.
PØAP	DBS	Appended load vectors on omitted points.
PØI	DBM	$\{P_o^i\}$ - Partition of inertia relief load vector.
PØINT	IB	Eivenvalue analysis normalization option for eigenvectors - see EIGR, EIGC, EIGB cards.

PØINTAX	IB	Axisymmetric Point.
PØØL	M	Pool file used by file allocator.
PØSITIØN	IS	Specifies initial position of input file.
PØUT$	M	Indicates restart with a printer output request.
PØVE	DBS	Load vectors on points omitted during matrix reduction.
PPF	DBM	Dynamic loads for frequency response.
PPHIG	DBM	Eigenvector components used to plot deformed shape. (D-3, D-5).
PPT	DBM	Linear dynamic loads for transient analysis.
PQDMEM	IB	Quadrilateral membrane element property definition card.
PQDMEM1	IB	Isoparametric quadrilateral membrane element property definition card.
PQDMEM2	IB	Quadrilateral membrane element property definition card.
PQDPLT	IB	Quadrilateral bending element property definition card.
PQUAD1	IB	General quadrilateral element property definition card.
PQUAD2	IB	Homogeneous quadrilateral element property definition card.
PREC	P	Precision of computer IBM = 2 UNIVAC = 2 CDC = 1
PRECHK	EM	Predefined automated checkpoint.
Preface	PH	Executive routines which are executed prior to the execution of the first module in a DMAP sequence. The Preface consists of the executive routines necessary to generate initial NASTRAN operational data and tables. The primary Preface routines are GNFIAT, XCSA, IFP1, XSØRT, IFP, IFP3, and XGPI.
PREFIX	IS	Prefix to rename equivalenced lower level substructures.
PRESAX	IB	Defines static pressure loading for the conical shell element.
PRESPT	IB	Defines a point in a hydroelastic model for output purposes.
PRESSURE	IC	Request for output of pressure and displacement vector or eigenvector for a hydroelastic problem.
PRINT	IA	Used to list all problem decks from UMF and Summary Table of Contents.
PRINT	IS	Stores modal or solution data and prints data requested.
PRINT	PU	Controls printing of flutter summary.
Problem Tape	PH	A magnetic tape containing data necessary for NASTRAN problem restarts. A tape being generated is designated as the New Problem Tape (NPTP) and its content is largely controlled by the DMAP instruction CHKPNT. This same tape when used as input to a subsequent NASTRAN restart is designated as the Old Problem Tape (ØPTP).

PRØD	IB	Rod property definition card.
PRØJECTIØN PLANE SEPARATIØN	IC	Separation of observer and projection plane for structure plots.
PRTMSG	FMS	Message generator.
PRTPARM	FMU	Prints DMAP diagnostic messages and parameter values.
PS	DBM	$\{P_s\}$ - Partition of static load vector.
PSDF	DBM	Power Spectral Density Function table.
PSDF	IC	Request for output of Power Spectral Density Function in Random Analysis (D-9, D-11).
PSDL	DBT	Power Spectral Density List.
Pseudo Modified Restart	PH	Restarting (see Restart) a NASTRAN problem and redirecting its solution but only affecting output data.
PSF	DBM	Partition of load vector for transient analysis.
PSHEAR	IB	Shear panel property definition card.
PST	DBM	Partition of linear load vector for transient analysis.
PTITLE	IC	Structure plot frame title.
PTØRDRG	IB	Toroidal ring property definition card.
PRTBSC	IB	Basic bending triangular element property definition card.
PTRIA1	IB	General triangular element property definition card.
PTRIA2	IB	Homogeneous triangular element property definition card.
PTRIM6	IB	Linear strain triangular membrane property.
PTRMEM	IB	Triangular membrane element property definition card.
PTRPLT	IB	Triangular bending element property definition card.
PTRPLT1	IB	Triangular plate property.
PTRSHL	IB	Higher order triangular shell element property.
PTUBE	IB	Tube property definition card.
PTWIST	IB	Twist panel property definition card.
PUBGV1	DBT	Displacement vector components used to plot deformed shape (D-4, D-5).
PUGV	DBT	Displacement vector components used to plot deformed shape (D-1, D-2).
PUGV1	DBT	Displacement components used to plot deformed shape (D-6).
PUNCH	IA	Used to punch the problem deck from UMF or copy the problem deck from UMF onto NUMF and punch it.

PUNCH	IC	Output media request (PRINT or PUNCH)
PUNPRT	IA	Used to punch and print the problem deck from UMF or copy the problem deck from UNF onto NUMF and punch and print it.
PURGE	EM	DMAP statement which causes conditional purging of data blocks.
Purge	PH	A data block is said to be purged when it is flagged in the FIAT so that it will not be allocated to a physical file and so that modules attempting to access it will be signaled.
PUVPAT	DBT	Displacement vector used for plots, PA-set for aeroelastic
PVEC	DBS	Load vectors.
PVISC	IB	Viscous element property definition card.
PVT	PH	Parameter value table. The PVT contains BCD names and values of all parameters input by means of PARAM bulk data cards. It is generated by the preface module IFP and is written on the Problem Tape.
P1	PU	INPUTT2 rewind option.
P2	PU	INPUTT2 unit number.
P3	PU	INPUTT2 tape id.

Q	PU	Parameter which defines the dynamic pressure.
QBDY1	IB	Defines uniform heat flux into HBDY elements.
QBDY2	IB	Defines grid point heat flux into HBDY elements.
QBG	DBM	Single point forces of constraint in the Differential Stiffness Rigid Format (D-4).
QDMEM	IC	Requests structure plot for all QDMEM elements.
QDMEM1	IC	Requests structure plot for all QDMEM1 elements.
QDMEM2	IC	Requests structure plot for all QDMEM2 elements.
QDPLT	IC	Requests structure plot for all QDPLT elements.
QG	DBM	Constraint forces for all grid points.
QHBDY	IB	Defines thermal load for steady-state heat conduction.
QHHL	DBML	Aerodynamic matrix list - h-set.
QHJL	DBML	Aerodynamic matrix for gust calculations.
QJHL	DBML	Aerodynamic transformation matrix between h and j sets.
QKHL	DBML	Aerodynamic matrix for aerodynamic force data recovery.
QP	DBM	Constraint forces for all physical points.
QPA	DBM	Constraint forces, PA-set.
QPAC	DBM	Constraint forces, complex, PA-set.
QPC	DBM	Complex single point forces of constraint for all physical points.
QPP2	DBT	Aerodynamic transient load output, sort 2.
QR	DBM	$\{q_r\}$ - Determinant support forces.
QS	DBM	$\{q_s\}$ - Single-point constraint forces.
QUAD1	IC	Requests structure plot for all QUAD1 elements.
QUAD2	IC	Requests structure plot for all QUAD2 elements.
QVEC	DBS	Reaction force vectors.
QVECT	IB	Defines thermal vector flux from distant source.
QVØL	IB	Defines volume heat generation.

R	P	Parameter value used by MATGPR to print R-set matrices.
R1	IC	Request for X-Y plot of the first rotational component (UM-4.2).
R1IP	IC	Request for X-Y plot of the first rotational component - imaginary and phase angle (UM-4.2).
R1RM	IC	Request for X-Y plot of the first rotational component - real and magnitude (UM-4.2).
R2	IC	Request for X-Y plot of the second rotational component (UM-4.2).
R2IP	IC	Request for X-Y plot of the second rotational component - imaginary and phase angle (UM-4.2).
R2RM	IC	Request for X-Y plot of the second rotational component - real and magnitude (UM-4.2).
R3	IC	Request for X-Y plot of the third rotational component (UM-4.2).
R3IP	IC	Request for X-Y plot of the third rotational component - imaginary and phase angle (UM-4.2).
R3RM	IC	Request for X-Y plot of the third rotational component - real and magnitude (UM-4.2).
RADLIN	P	Controls linearization of radiation effects in transient heat transfer analysis.
RADLST	IB	List of radiation areas.
RADMTX	IB	Radiation exchange coefficients.
RANDØM	IC	Selects the RANDPS and RANDT cards to be used in random analysis.
RANDØM	FMS	Random response solution generator.
RANDPS	IB	Power spectral density specification.
RANDT1	IB	Autocorrelation function time lag.
RANDT2	IB	Autocorrelation function time lag.
RANGE	IS	Identifies frequency range for real or complex retained modal coordinates.
RBMG1	FMS	Rigid body matrix generator - part 1.
RBMG2	FMS	Rigid body matrix generator - part 2.
RBMG3	FMS	Rigid body matrix generator - part 3.
RBMG4	FMS	Rigid body matrix generator - part 4.
RCØVR	FMSS	Recover Phase 2 substructure results.
RCØVR3	FMSS	Recover substructure results for Phase 3.
REACT	P	Flag for rigid body mode calculations.

READ	FMS	Real Eigenvalue Analysis - Displacement.
REAL	IC	Requests real and imaginary form of complex quantities.
REAL EIGENVALUES	IA	Selects rigid format for normal mode analysis.
RECØVER	IS	Phase 2 solution data recovery or Phase 1, 2 modal reduction request.
REDUCE	FMSS	Reduction of substructure degrees of freedom.
REDUCE	IS	Phase 2 reduction to retained degrees of freedom request.
REEL	IA	Term appearing on the checkpoint dictionary cards indicating the physical reel on which a data block appears.
Reentry Point	PH	The point in the DMAP sequence at which a problem terminated and hence the point at which it can be restarted (see Restart).
REGIØN	IC	Specifies portion of frame to be used for structure plot.
REIG	P	Parameter used in SDR2 to indicate Normal Mode Analysis (D-3).
RELES	IB	Specifies grid point degrees of freedom to be disconnected - overrides CØNCT and automatic connectivities using substructuring.
REMØVE	IA	Used to copy problem decks from UMF onto NUMF up to pid and skip over problem pid.
REPCASE	IC	Allows another output request for the previous subcase (D-1, D-2).
REPEAT	P	Controls looping in Static Analysis (D-1, D-2).
REPEATD	P	Controls looping in Static Analysis with Differential Stiffness (D-4).
REPEATE	P	Controls looping in Complex Eigenvalue Analysis (D-7, D-10).
REPEATF	P	Controls looping in Frequency Response Analysis (D-8, D-11).
REPEATT	P	Controls looping in Transient Response Analysis (D-9, D-12).
REPT	EM	DMAP statement to conditionally repeat a loop.
RESPØNSE	IC	Request for X-Y plot of any response outputs from transient or frequency response analysis (D-8, D-9, D-11, D-12).
RESTART	IA	First control card of checkpoint dictionary. Contains identification of checkpoint tape.
Restart	PH	Initiating a NASTRAN problem solution at a place other than its logical beginning by utilizing an Old Problem Tape created during a previous run.
RESTØRE	IS	Reloads the SØF from an external file.
RFØRCE	IB	Rotational force definition card.
RFØRCE$	M	Indicates restart with change in rotational force.
RG	DBM	Multipoint constraint equations.

RGRID	IS	Specifies grid point in the basic substructure to define reference point for inertia relief shapes. Defaults to origin of basic substructure coordinate system.
RIGHT TICS	IC	Request for tic marks to be plotter on right hand edge of frame for X-Y plots.
Rigid Format	PH	A fixed prestored DMAP sequence and its associated restart tables which perform a specific problem solution.
Rigid Format Switch	PH	A type of restart (see Restart) in which the problem is changed from one Rigid Format to another.
RINGAX	IB	Conical shell ring definition card.
RINGFL	IB	Hydroelastic axisymmetric point definition card.
RLØAD1	IB	Frequency response load set definition.
RLØAD2	IB	Frequency response load set definition.
RMG	FMH	Radiation matrix generator - generates $[R_{gg}]$.
RNAME	IS	Specifies basic substructure to define reference point for inertia.
RØD	IC	Requests structure plot for all RØD elements.
RP	DBM	Partitioning vector set D to A and E.
RSAVE	IS	Save REDUCE decomposition product or indicates the decomposition product of the interior point stiffness.
RUBLV	DBM	Residual vector - Differential Stiffness Rigid Format (D-4).
RULV	DBM	Residual vector for independent degrees of freedom.
RUN	IS	Specifies run options.
RUØV	dbm	residual vector for omitted degrees of freedom.
RXY	IC	Requests vector sum of X and Y deformation components for structure plot.
RXYZ	IC	Requests vector sum of X, Y and Z deformation components for structure plot.
RXZ	IC	Requests vector sum of X and Z deformation components for structure plot.
RYX	IC	Requests vector sum of Y and Z deformation components for structure plot.

S	P	Parameter value used by MATGPR to print S-set matrices.
SACCE	IC	Abbreviated form of SACCELERATIØN.
SACCELERATIØN	IC	Output request for solution set acceleration vector. (UM-2.3, 4.2)
SAVE	EM	DMAP statement which causes current value of parameter to be saved.
SAVE	IS	Stores modal or solution data on SØF.
SAVE	M	Save data block for possible looping in DMAP sequence (see FILE).
SAVEPLØT	IS	Requests plot data be saved in Phase 1.
SC	IC	Selects SC 4020 plotter.
SCALAR	FMU	Convert matrix element to parameter.
Scalar Point	PH	A point which is defined on an SPØINT, CELAS1, CELAS2, CELAS3, CELAS4, CMASS1, CMASS2, CMASS3, CMASS4, CDAMP1, CDAMP2, CDAMP3, or CDAMP4 bulk data card. A scalar point has no geometrical coordinates and defines only one degree of freedom of the model.
SCALE	IC	Selects scale for structure plot.
SCE1	FMS	Single-point Constraint Eliminator.
SDAMP	IC	Modal structural damping table selection.
SDAMP4	M	Indicates restart with change in modal damping.
SDAMPING	IC	Selects table which defines damping as a function of frequency in modal formulation problems.
SDISP	IC	Abbreviated form of SDISPLACEMENT.
SDISPLACEMENT	IC	Output request for solution set displacement vector. (UM-2.3, 4.2)
SDR1	FMS	Stress Data Recovery - part 1.
SDR2	FMS	Stress Data Recovery - part 2.
SDR3	FMS	Stress Data Recovery - part 3.
SDRHT	FMH	Heat flux data recovery.
SEARCH	IS	Limits search for automatic connects.
SECTAX	IB	Defines conical shell sector for data recovery.
SEEMAT	FMU	Prints pictorial representation of matrix showing location of nonzero elements.
SEM1	M	The NASTRAN Preface.
SEQEP	IB	Extra point resequencing.
SEQGP	IB	Grid or scalar point resequencing.

SET	IC	Definition of a set of elements, grid and/or scalar and/or extra points, frequencies, or times to be used in selecting output.
SET1	IB	Defines a set of structural grid points by a list.
SET2	IB	Defines a set of structural grid points by aerodynamic macro elements.
SETVAL	FMU	Parameter value initiator.
SGEN	FMSS	Substructure table generator.
SHEAR	IC	Requests structure plot for all shear panel elements.
SIGMA	PU	Defines Stefan-Boltzmann constant in heat transfer analysis.
SIL	DBT	Scalar Index List for all grid points and extra scalar points introduced for dynamic analysis.
SILGA	DBT	Scalar Index List - Aerodynamic boxes only.
SINCØN	PU	Controls the automatic stiffness matrix singularity removal.
SINE	IC	Conical shell request for sine set boundary conditions.
SING	P	-1 if $[K_{oo}]$ is singular.
SINGLE	P	No single-point constraints.
SKIP BETWEEN FRAMES	IC	Request to insert blank frames on SC 4020 plotter for X-Y plots.
SKJ	DBM	Integration matrix.
SKPMGG	P	Parameter used in statics to control execution of functional module SMA2.
SKPPLT	L	Used to skip plot.
SLBDY	IB	Defines list of points on interface between axisymmetric fluid and radial slots.
SLØAD	IB	Scalar point load definition.
SLT	DBT	Static Loads Table.
SMA1	FMS	Structural Matrix Assembler - phase 1 - generates stiffness matrix $[K_{gg}]$ and structural damping matrix $[K^4_{gg}]$.
SMA2	FMS	Structural Matrix Assembler - phase 2 - generates mass matrix $[M_{gg}]$ and viscous damping matrix $[B_{gg}]$.
SMA3	FMS	Structural Matrix Assembler - phase 3 - add general element contributions to the stiffness matrix $[K_{gg}]$.
SMP1	FMS	Structural Matrix Partitioner - part 1.
SMP2	FMS	Structural Matrix Partitioner - part 2.
SMPYAD	FMM	Performs multiply-add matrix operation for up to five multiplications and one addition.

SØF	IS	Assigns physical files for storage of the SØF.
SØFI	FMSS	SØF into GINØ matrix copier.
SØFIN	IS	Copies substructure items from an external file to the SØF.
SØFØ	FMSS	SØF out from GINØ matrix copier.
SØFØUT	IS	Copies substructure items from the SØF to an external file.
SØFPRINT	IS	Prints selected contents of the SØF.
SØFUT	FMSS	SØF utility module.
SØL	IA	Specifies which rigid format solution is to be used when APP is DISPLACEMENT.
SØLN	DBS	Load factor data or eigenvalues used in a solution.
Solution Points	PH	Points used in the formulation of the general K system.
SØLVE	FMM	Solves a set of linear algebraic equations.
SØLVE	IS	Requests substructure solution.
SØRT	IS	Output sort order.
SØRT1	IC	Output is sorted by frequency or time and then by external ID.
SØRT2	IC	Output is sorted by external ID and then by frequency or time.
SØRT3	M	Output is sorted by individual item or component and then by frequency or time.
SPC	IB	Single-point constraint and enforced deformation definition.
SPC	IC	Selects set of single-point constraints for structural displacements or heat transfer boundary temperatures.
SPC$	M	Indicates restart with change in single-point constraint set selection.
SPC1	IB	Single-point constraint definition.
SPCADD	IB	Single-point constraint set combination definition.
SPCAX	IB	Conical shell single-point constraint definition.
SPCF	IC	Abbreviated form of SPCFØRCE.
SPCF	IS	Reaction force output request.
SPCFØRCE	IC	Requests the single-point forces of constraint at a set of points or the thermal power transmitted to a selected set of points in heat transfer.
SPCS	IB	Specifies single point constraints for substructuring.
SPCS1	IB	Alternate specification of single point constraints for substructuring.
SPCSD	IB	Specifies enforced displacements for single point constraints for substructuring.

Spill	PH	Secondary storage devices are used because there is insufficient main storage to perform a matrix calculation or a data processing operation.
SPLINE	DBT	Splining Data Table.
SPLINE1	IB	Defines surface spline.
SPLINE2	IB	Defines beam spline.
SPLINE3	IB	User data to interpolate deflections at aerodynamic degrees of freedom.
SPØINT	IB	Scalar point definition card.
SSG1	FMS	Static Solution Generator - part 1.
SSG2	FMS	Static Solution Generator - part 2.
SSG3	FMS	Static Solution Generator - part 3.
SSG4	FMS	Static Solution Generator - part 4.
SSGHT	FMH	Solution generator for nonlinear heat transfer analysis.
STATIC	IC	Requests deformed structure plot for problem in Static Analysis.
STATIC ANALYSIS WITH CYCLIC SYMMETRY	IA	Selects rigid format for static analysis using cyclic symmetry.
STATIC HEAT TRANSFER ANALYSIS	IA	Selects rigid format for linear static analysis using heat transfer.
STATICS	IA	Selects statics rigid format for heat transfer or structural analysis.
STATICS	P	Parameter used in SDR2 to indicate Static Analysis.
STEADY STATE	IA	Selects rigid format for nonlinear static heat transfer analysis.
STEPS	IS	Frequency or time step output request for substructuring.
STEREØSCØPIC	IC	Requests stereoscopic projections for structure plot.
STRESS	IC	Requests the stresses in a set of structural elements or the velocity components in a fluid element in acoustic cavity analysis.
Structural Element	PH	One of the finite elements used to represent a part of a structure.
STST	NP	Defines the singularity tolerance in EMG.
SUBCASE	IC	Subcase definition.
SUBCASES	IS	Subcase output request.
SUBCØM	IC	This subcase is a linear combination of previous subcases.
SUBPH1	FMSS	Substructure, Plase 1.

SUBSEQ	IC	Specifies coefficients for SUBCØM subcases.
SUBSTRUCTURE	IS	Initiates the substructure control deck.
Substructure Control Deck	PH	One of the data decks required to run automated multi-stage substructuring. The deck begins with the SUBSTRUCTURE card and terminates with the ENDSUBS card. Cards in this deck cause the necessary alters to the Rigid Format DMAP.
SUBTITLE	IC	Output labeling data for printer output.
SUPAX	IB	Ficticious support for conical shell problem.
SUPØRT	IB	Ficticious support definition card.
SVECTØR	IC	Request for output of eigenvectors in the solution set (D-7, D-10) (UM-2.3, 4.2).
SVELØ	IC	Abbreviated form of SVELØCITY.
SVELØCITY	IC	Requests velocity output for solution set. (UM-2.3, 4.2)
SWITCH	FMU	Interchange two data block names.
SYM	IC	Symmetry subcase delimiter card.
SYMBØLS	IC	Requests symbols at grid points on structure plot.
SYMCØM	IC	Assembly of symmetry subcase delimiter card.
SYMSEQ	IC	Assembly value of symmetry combination card.
SYMTRANSFØRM	IS	Specifies symmetry transformation.

T1	IC	Request for X-Y plot of the first translational component (UM-4.2).
T1IP	IC	Request for X-Y plot of the first translational component - imaginary and phase angle (UM-4.2).
T1RM	IC	Request for X-Y plot of the first translational component - real and magnitude (UM-4.2).
T2	IC	Request for X-Y plot of the second translational component (UM-4.2).
T2IP	IC	Request for X-Y plot of the second translational component - imaginary and phase angle (UM-4.2).
T2RM	IC	Request for X-Y plot of the second translational component - real and magnitude (UM-4.2).
T3	IC	Request for X-Y plot of the third translational component (UM-4.2).
T3IP	IC	Request for X-Y plot of the third translational component - imaginary and phase angle (UM-4.2).
T3RM	IC	Request for X-Y plot of the third translational component - real and magnitude (UM-4.2).
TA1	FMS	Table Assembler.
TABDMP1	IB	Tabular structural damping function for modal formulation (D-10, D-11, D-12).
Table Data Block	PH	A data block which is in tabular form rather than matrix form.
TABLED1	IB	Dynamic load tabular function (D-8, D-9, D-11, D-12).
TABLED2	IB	Dynamic load tabular function (D-8, D-9, D-11, D-12).
TABLED3	IB	Dynamic load tabular function (D-8, D-9, D-11, D-12).
TABLED4	IB	Dynamic load tabular function (D-8, D-9, D-11, D-12).
TABLEM1	IB	Material property tabular function.
TABLEM2	IB	Material property tabular function.
TABLEM3	IB	Material property tabular function.
TABLEM4	IB	Material property tabular function.
TABLES1	IB	Stress-dependent material tabular function for use in Piecewise Linear Analysis (D-6).
TABPCH	FMU	Punches selected tables on DTI bulk data cards.
TABPRT	FMU	Formats selected table data blocks for printing.
TABPT	FMU	Table printer.
TABRNDG	IB	Table of Power Spectral Density for certain gusts.
TABRND1	IB	Tabular function for use in Random Analysis (D-8, D-11).
TABRND2	IB	Tabular function for use in Random Analysis (D-8, D-11).

TABRND3	IB	Tabular function for use in Random Analysis (D-8, D-11).
TABRND4	IB	Tabular function for use in Random Analysis (D-8, D-11).
TABS	P	Defines absolute reference temperature in heat transfer analysis.
TALL EDGE TICS	IC	Request for plotting all edge tic marks on upper half frame for X-Y plots.
TAPE	M	Write data block on physical tape (see FILE).
TCURVE	IC	Curve title for X-Y plot.
TEMP	IB	Grid temperature definition card.
TEMPAX	IB	Temperature definition for conical shell problem.
TEMPD	IB	Grid default temperature definition card.
TEMPERATURE	IC	Selects thermal field for determining both equivalent static loads and material properties.
TEMPLD$	M	Indicates restart with change in thermal set for static loading.
TEMPMT$	M	Indicates restart with change in thermal set for material properties.
TEMPMX$	M	Indicates restart with change in thermal field with thermally dependent material properties.
TEMP(LØAD)	IC	Selects thermal field to be used for determining equivalent static loads.
TEMP(MAT)	IC	Selects thermal field to be used for determining structural material properties or an estimate of the temperature distribution for heat transfer iterations.
TEMPP1	IB	Plate element temperature definition card.
TEMPP2	IB	Plate element temperature definition card.
TEMPP3	IB	Plate element temperature definition card.
TEMPRB	IB	One-dimensional element temperature definition.
TF	IB	Dynamic transfer function definition.
TF$	M	Indicates restart with change in transfer function set selection.
TFL	IC	Transfer function set selection.
TFPØØL	DBT	Transfer function pool.
THERMAL	IC	Request for output of temperature vector in thermal analysis (UM-2.3).
THRU	IC	Forms strings of values within set declarations.
TIC	IB	Transient Initial Condition set definition card.

TIME	IA	User time estimate for problem. This card if required in Executive Control Deck. Integer time value is in minutes.
TIMETEST	FMU	Provides NASTRAN system timing data.
TITLE	IC	Output labeling data for printer output.
TLEFT TICS	IC	Request for tic marks to be plotted on left hand edge of top half frame for X-Y plot.
TLØAD1	IB	Transient load set definition card.
TLØAD2	IB	Transient load set definition card.
TØC	IA	Used to list all problem decks (Summary Table of Contents) by UMF number from UMF.
TØL	DBT	Time output list.
TØL1	DBT	Reduced time output list, uses ØTIME.
TØLERANCE	IS	Limits distance between automatically connected grids.
TRACKS	NP	Defines the format for the number of tracks required for plot data.
Trailer	PH	A six word control block associated with a data block.
TRANRESP	P	Parameter used in SDR2 to indicate Transient Response Analysis (D-9, D-12).
TRANS	IB	Specifies coordinate systems for substructure and grid point transformation.
TRANSFØRM	IS	Defines transformations for named component substructures.
TRANSIENT	IA	Selects rigid format for transient heat transfer analysis.
TRANSIENT HEAT TRANSFER ANALYSIS	IA	Selects rigid format for linear transient analysis using heat transfer.
TRBSC	IC	Requests structure plot for all basic bending triangle elements.
TRD	FMS	Transient Response - Displacement.
TRHT	FMH	Integrates dynamic equation for heat transfer analysis.
TRIA1	IC	Requests structure plot for all TRIA1 elements.
TRIA2	IC	Requests structure plot for all TRIA2 elements.
TRIGHT TICS	IC	Request for tic marks to be plotted on right hand edge of top half frame for X-Y plots.
TRL	DBT	Transient Response List.
TRLG	FMH	Generates dynamic heat flux loads.
TRMEM	IC	Requests structure plot for all triangular membrane elements.
TRNSP	FMM	Transpose functional module.

TRPLT	IC	Request structure plot for all TRPLT elements.
TSTART	P	CPU time at start of flutter loop.
TSTEP	IB	Transient time steps for integration and output.
TSTEP	IC	Transient time step set selection.
TSTEP$	M	Indicates restart with change in transient time step set selection.
TUBE	IC	Requests structure plot for all TUBE elements.
TWIST	IC	Requests structure plot for all TWIST elements.
TYPE	IC	Indicates paper type for structure plots.

UBGV	DBM	Displacement vector for all grid points (D-4).
UBLL	DBM	$[U^b_{\ell\ell}]$ - Upper triangular factor of $[K^b_{\ell\ell}]$.
UBLV	DBM	Displacement solution vector (D-4).
UBØØV	DBM	Scalar multiple of UØØV in Differential Stiffness Rigid Format (D-4).
UDET	IB	Selects unsymmetric decomposition option for determinant method of real eigenvalue analysis.
UDV1T	DBM	Displacement, velocity and acceleration solution vectors in a transient analysis problem - SØRT1. (D-9)
UDV2T	DBM	Displacement, velocity and acceleration solution vectors in a transient analysis problem - SØRT2 (D-9).
UDVF	DBM	Displacement solution vector in a frequency response problem (D-8).
UDVT	DBM	Displacement, velocity and acceleration solution vectors in a transient analysis problem (D-9).
UEVF	DBM	Displacement vector for extra points in a frequency response problem (D-11).
UEVT	DBM	Displacement vector for extra points in a transient response problem (D-12).
UGV	DBM	Displacement vector for all grid points (D-1, D-2, D-4, D-5).
UGV1	DBM	Successive sums of incremental displacement vectors. Piecewise Linear Analysis Rigid Format only (D-6).
UHVF	DBM	Modal frequency response solution vectors (D-11).
UHVT	DBM	Modal transient response solution vectors (D-12).
UHVT1	DBM	Modal amplitudes for aeroelastic transient.
UIMPRØVE	IS	Improved displacement request.
UINV	IB	Selects unsymmetric decomposition option for inverse power method of eigenvalue analysis.
ULL	dbm	$[U_{\ell\ell}]$ - Upper triangular factor of $[K_{\ell\ell}]$.
ULV	DBM	Displacement solution vector in static analyses (D-1, D-2, D-4, D-5).
UMERGE	FMM	Functional module to merge column matrices based on U-set.
UMF	IA	Used to copy UMF problem deck onto NUMF, list it and punch UMF card.
UMF	M	User Master File, a reserved NASTRAN physical file which must be set up by the user when used.
UMFEDIT	IA	Requests User Masetr File operational mode of NASTRAN.
Unmodified Restart	PH	Restarting (see Restart) a problem without changing any data, other than output requests, of the previous run.

Unpool	PH	Remove data block from Pool Tape and place on a file for use by a functional module.
UNSØRT	IC	Requests unsorted echo of Bulk Data Deck (ECHØ=UNSØRT).
UØØ	DBM	$[U_{oo}]$ - Upper triangular factor of $[K_{oo}]$.
UØØV	DBM	Partition of displacement solution vector.
UPARTN	FMM	Functional module to partition matrices based on U-set.
UPPER TICS	IC	Request for tic marks to be plotted on upper edge of frame for X-Y plot.
UPRT	DBS	Partitioning vector used in matrix reduction.
UPV	DBM	Transient solution vectors for all physical points.
UPVC	DBM	Frequency response solution vectors for all physical points.
USERMØDES	is	Flag to indicate modal data have been input on bulk data.
USET	DBT	Displacement set definitions. (PM-1.7.3)
USETA	DBT	Displacement set definitions table - Aerodynamics.
USETD	DBT	Displacement set definitions including extra scalar points.
UVEC	DBS	Displacement vectors or eigenvectors.
UVT1	DBM	Displacements for aeroelastic transient.

V	DBM	Partitioning vector for set F to Ø and A.
V	M	Used in parameter section of DMAP statement. Indicates that parameter is variable and may be changed by module. If changed value is to be used in subsequent DMAP instruction, it must be saved (see SAVE).
VANTAGE PØINT	IC	Location of observer for structure plot.
VDR	FMS	Vector Data Recovery.
VDR	L	Used to skip to VDR module in flutter analysis.
VEC	FMU	Creates partitioning vector based on USET.
VECTØR	IC	Request for output of eigenvectors from real or complex eigenvalue analysis (D-3, D-5, D-7, D-10).
VECTØR	IC	Requests displacements for a selected set of PHYSICAL points.
VELØ	IC	Abbreviated form of VELØCITY.
VELØ	IS	Velocity output request.
VELØCITY	IC	Output request statement for velocity vector. (UM-2.3, 4.2).
VFS	DBM	Partitioning vector for heat transfer analysis.
VIEW	IC	Rotation of object for structure plot.
VISC	IC	Request structure plot for all viscous damper element.
VPS	M	See XVPS.
VREF	PU	Velocity division factor.

W3	PU	Pivotal frequency for uniform structure damping in the direct formulation of transient response problems (D-9).
W4	PU	Pivotal frequency for element structural damping in the direct formulation of transient response problems (D-9).
WTMASS	PU	Weight to mass conversion factor used in SMA2 and GPWG. Default value is 1.0.

X	IC	Requests X vector for deformed structure plot.
XAXIS	IC	Request for drawing of X-axis for X-Y plot.
XBAXIS	IC	Request for drawing of X-axis on bottom half frame for X-Y plot.
XBGRID LINES	IC	Request for drawing grid lines for X-axis on bottom half frame for X-Y plot.
XCSA	EM	Executive Control Section Analysis. The preface module which processes the Executive Control Deck and prepares the control file on the New Problem Tape.
XDIVISIØNS	IC	Request for division marking on X-axis.
XDMAP	EM	Controls the DMAP compiler options.
XGPI	EM	Executive General Problem Initialization. The preface module whose principal function is to generate the ØSCAR. If the problem is a restart, XGPI initializes data blocks and named common blocks for proper restart.
XGRID LINES	EC	Request for grid lines to be drawn on X-axis for X-Y plots.
XINTERCEPT	IC	Specifies intercept of Y-axis on X-axis.
XLØG	IC	Request for logarithmic scales in X-direction.
XMAX	IC	Do not plot points whose X value lies above this value.
XMIN	IC	Do not plot points whose X value lies below this value.
XPAPER	IC	Specifies length of paper in X-direction for table plotter.
XQHHL	P	Appended QHHL data parameter.
XSFA	EM	Executive Segment File Allocator - the administrative manager of data blocks for NASTRAN.
XSØRT	EM	Executive sort routine - the preface module which reads and sorts the Bulk Data Deck and writes the sorted Bulk Data Deck on the New Problem Tape.
XTAXIS	IC	Request for drawing of X-axis on top half frame.
XTGRID LINES	IC	Request for drawing of grid lines on top half frame.
XTITLE	IC	X-axis title for X-Y plots.
XVALUE PRINT SKIP	IC	Request to suppress labeling tic marks over the specified interval.
XVPS	M	Variable Parameter Set Table. Executive table needed for restart. (PM-2.4)
XY	IC	Requests X and Y vectors for deformed structure plot.
XYCDB	DBT	SØRT3 type output requests (XYPLØTTER, XYPRINTER, Random Request).
XYØUT	IC	Request to generate X-Y plots.

XYØUT$	M	Indicates restart with an X-Y plot request.
XYPEAK	IC	Request to print the maximum and minimum values of the specified response.
XYPLTCE	DBT	XY plot input data block, complex flutter.
XYPLØT	FMS	X-Y plot generator.
XYPLØT	IC	Request to generate X-Y plots.
XYPLTF	DBT	XYPLØT input data block. (D-8, D-11)
XYPLTFA	DBT	XYPLØT input data block. (D-8, D-11)
XYPLTR	DBT	XYPLØT input data block. (D-8, D-11)
XYPLTT	DBT	XYPLØT input data block. (D-9, D-12)
XYPLTTA	DBT	XYPLØT input data block. (D-9, D-12)
XYPRINT	IC	Request to tabulate XY pairs on the printer.
XYPRNPLT	FMX	Dummy output module.
XYPTTA	DBT	XY plot input data block, aeroresponse.
XYPUNCH	IC	Request to punch XY pairs.
XYTRAN	FMS	XY output translator.
XYZ	IC	Requests X, Y and Z vectors for deformed structure plot.
XZ	IC	Requests X and Z vectors for deformed structure plot.

Y	IC	Requests Y vector for deformed structure plot.
Y	M	Used in parameter section of DMAP statement. Indicates that parameter may be given an initial value with a PARAM bulk data card.
YAXIS	IC	Request for drawing of Y-axis.
YBDIVISIØNS	IC	Request for division marking on Y-axis of lower half frame.
YBGRID LINES	IC	Request for grid lines to be drawn on Y-axis of lower half frame.
YBINTERCEPT	IC	Specifies intercept of X-axis on Y-axis on lower half frame.
YBLØG	IC	Request for logarithmic scales in Y-direction on lower half frame.
YBMAX	IC	Do not plot points whose Y value lies above this value for lower half frame.
YBMIN	IC	Do not plot points whose Y value lies below this value for lower half frame.
YBS	DBM	Scalar multiple of YS matrix. Used in Differential Stiffness Rigid Format only. (D-4).
YBTITLE	IC	Y-axis title on lower half frame.
YBVALUE PRINT SKIP	IC	Request to suppress labeling tic marks over the specified interval.
YDIVISIØNS	IC	Request for division marking on Y-axis.
YES	IA	Option used on CHKPNT card, indicates that checkpoint is desired.
YGRID LINES	IC	Request for grid lines to be drawn on Y-axis.
YINTERCEPT	IC	Specifies intercept of X-axis on Y-axis.
YLØG	IC	Request for logarithmic scales in Y-direction.
YMAX	IC	Do not plot points whose Y value lies above this value.
YMIN	IC	Do not plot points whose Y value lies below this value.
YPAPER	IC	Specifies length of paper in Y-direction for table plotter.
YS	DBM	$\{Y_s\}$ - Constrained displacement vector.
YTDIVISIØNS	IC	Request for division marking on Y-axis for upper half frame.
YTGRID LINES	IC	Request for grid lines to be drawn on Y-axis for upper half frame.
YTINTERCEPT	IC	Specifies intercept of X-axis on Y-axis for upper half frame.
YTITLE	IC	Y-axis title.
YTLØG	IC	Request for logarithmic scales in Y-direction for upper half frame.

YTMAX	IC	Do not plot points whose Y value lies above this value for upper half frame.
YTMIN	IC	Do not plot points whose Y value lies below this value for upper half frame.
YTITLE	IC	Y-axis title for upper half frame.
YTVALUE PRINT SKIP	IC	Request to suppress labeling tic marks over the specified interval for upper half frame.
YVALUE PRINT SKIP	IC	Request to suppress labeling tic marks over the specified interval.
YZ	IC	Requests Y and Z vectors for deformed structure plot.
Z	IC	Requests Z vector for deformed structure plot.

*U.S GOVERNMENT PRINTING OFFICE: 1979--636-677/1476